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A BOTANICAL FORAY TO THE FOX ISLANDS, NORTHERN LAKE MICHIGAN

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A memorable adventure began on July 18, 1984 when the authors departed Mackinaw City aboard the *Noble Odyssey, YP-587,* and embarked for the Fox Islands in northern Lake Michigan. The Foxes (Figure 1) lie 17 miles from the nearest mainland, Cathead Pt. on the Leelanau Peninsula, and form a small group between the Beavers (11 miles to the northeast) and the Manitous (17 miles to the south-southwest). Fuller (1918, 1920) briefly noted the dune vegetation of South Fox, and a short vegetation description of both islands was included by Hatt et al. (1948). The vegetation of North Fox was described in greater detail by Wells et al. (1975), but voucher specimens were not collected due to time constraints. The only previous floristic documentation of almost 200 species of vascular plants from these islands had been done in the 1960s. Specimens at the University of Michigan Biological Station show that F. H. Test made collections on North Fox in July 1963 and on South Fox in June 1962. Other South Fox specimens were collected by E. U. Clover in July 1961 and by Larry Wolf in August 1961. One goal of our expedition was to update species records for these islands, in part to assist in the preparation of *Michigan Flora, Part 2* (Voss, 1985) as these islands are being mapped as a distinct unit apart from the rest of Leelanau Co.

The *Noble Odyssey, YP-587* (Fig. 2) is a U.S. Navy vessel operated as part of the U.S. Naval Sea Cadet Corps. This nation-wide program, sponsored by the civilian Navy League, is designed to train young people in nautical skills. The ship is operated entirely by cadets, ages 14–17, under the supervision of Captain Luther Clyburn and his officers. The *Odyssey's* home port, Mt. Clemens, Michigan, has been used by the Sea Cadets for 8 years. The ship was refurbished by Mr. Clyburn and volunteers after being saved from becoming scrap. The *YP-587* saw active service in WW II as a yard patrol vessel, hence its YP designation. The ship was next used as an instructional vessel until 1972 at the U.S. Naval Academy at Annapolis. Its historical value was enhanced by the onboard training of Midshipman James Earl Carter, who would later become the 39th President of the United States.

The wooden-hulled ship is 75 feet long and displaces 50 tons. It is powered by two 200 hp, Superior diesel engines and can attain a top speed of 11 knots under ideal conditions. Below deck are the officers' quarters, galley, and engine room. The bridge is located on the forward deck and the crew

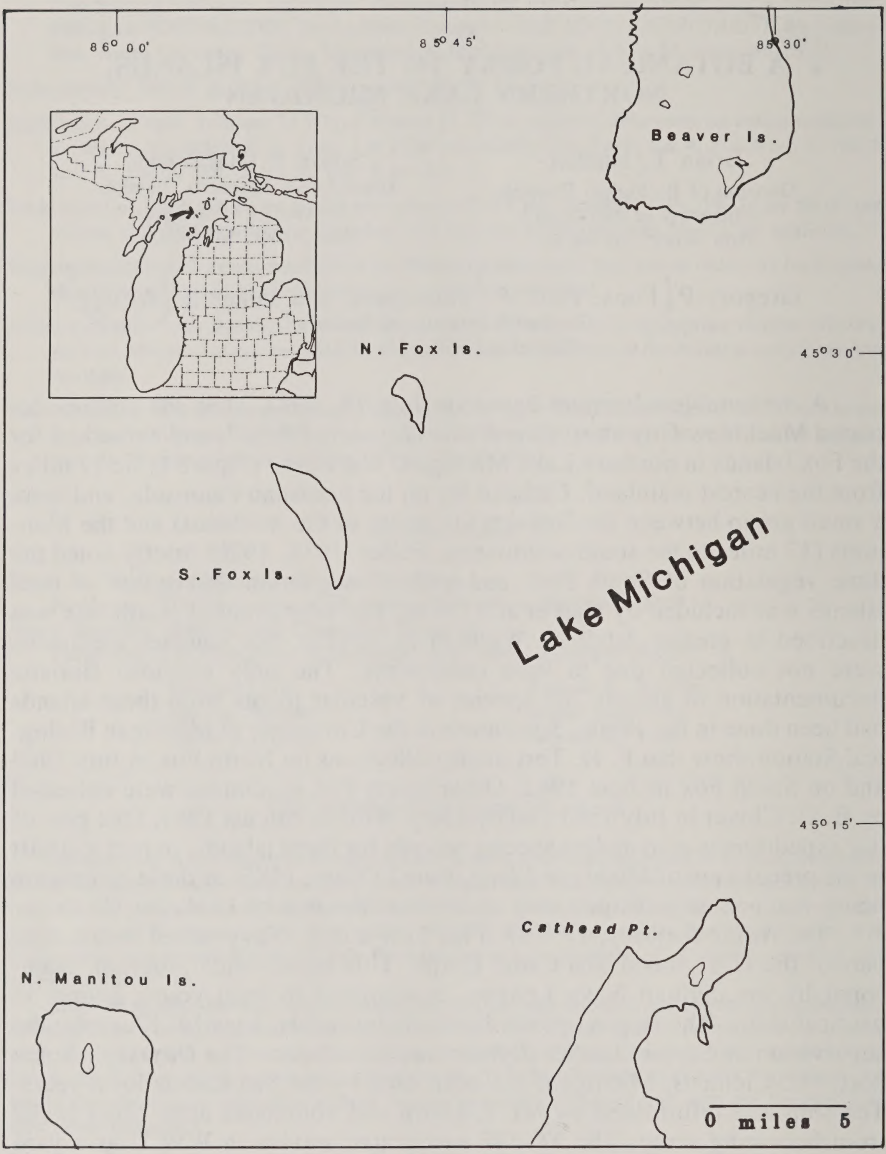

Fig. 1. North and South Fox Islands with inset showing their location in Lake Michigan.

quarters on the aft. The *Betty S,* a new outboard-motored inflatable Avon dingy recently donated by William Slaughter, benefactor of the Sea Cadet program, was carried above the crew's quarters and was used for the first time on this trip. For this expedition Capt. Clyburn maintained a crew of 14 cadets, 2 engineers, 3 officers, a cook, and a dive master.

Fig. 2. *Noble Odyssey* anchored off South Fox Island.

The *Odyssey* had been a part of other missions under the Sea Cadet Corps. One trip to Lake Superior included the exploration of the *Emperor,* a wrecked ore-carrier off the coast of Isle Royale. *Angels of the Sea,* a film documenting this trip was awarded 3rd place in international competition at the 1985 New York Film Festival.

Our six hour trip from Mackinaw City to South Fox was smooth and sunny, indicative of the weather we would have for the next few days. On this voyage we passed under the Mackinac Bridge, had a close view of White Shoal and Gray's Reef lighthouses, and finally passed by the Beaver Island group before reaching South Fox around 4:00 PM. We were delivered to the island in the *Betty S.* After stowing our gear in the remodeled lumbermen's bunk house, we hiked south along the east shore to the lighthouse and soon filled our collecting bags. As the sun set we returned to the *YP* for a small snack and then returned to the island. Our day ended at midnight after hours of sorting, recording, and pressing our first collections. Our island housing, originally built during the lumbering operations on the island, is now used by hunters in the fall who come to stalk the island's introduced deer herd. Its 14 bunks easily held our party of 5.

At breakfast the following morning, we agreed upon our assignments. Thompson and Hazlett would take the island's Honda all terrain cycle (ATC) to explore the north end. Hendricks would be taken north via the *Betty S* to search for beach pools and other aquatic habitats along Lake Michigan. Fons

and Wells would stay behind to instruct the cadets on botanical skills such as poison ivy identification and plant collecting.

Hazlett and Thompson eventually found themselves at the end of an interdunal valley which reminded them of the giant cedar grove on South Manitou. White cedar (*Thuja occidentalis*) was a major contributor to the overstory, although the trees did not approach the size of those on South Manitou. Soon after arriving at this site, a small clump of green spleenwort (*Asplenium viride*) was found on a mossy cedar log. Further searching showed this Michigan special concern species to be locally abundant on the mossy cedar logs throughout that end of this valley. The size of this population definitely surpassed that occurring on South Manitou, where only a small population consisting of around 30 fronds on the sandy soil of the forest floor of the cedar grove had been found (Hazlett & Vande Kopple 1983). The mossy log growth habit of *A. viride* on South Fox is similar to that of walking fern (*Camptosorus rhizophyllus*) on South Manitou. Further investigations of the interdunal valleys on South Fox may reveal this fern there as well. The discovery of Braun's holly-fern (*Polystichum braunii*) and ginseng (*Panax quinquefolius*) in this area illustrates additional similarities with the South Manitou flora.

Hendricks, meanwhile, had been dropped off 1.5 miles upshore from the settlement. Unsuccessful at finding aquatic habitats, she decided to ascend the steep bank and explore the northern hardwoods, collecting along the way. Coming upon the main trail, she unexpectantly met Hazlett and Thompson, just as they were ready to head back to the settlement. (After exploring the dunes near the interdunal valley, Thompson and Hazlett returned to the main trail, but had been stopped in their northward progress by a fallen tree). With a few additional vouchers the trio headed south (Fig. 3) on the ATC with Hazlett as the driver. On the way back, they stopped in a large clearing to examine a small water hole along the trail before completing the 2.5 mile route back to the settlement where they joined Fons and Wells who had been instructing the cadets in basic plant identification and collection. Greg and Jim had also given a short presentation in sand dune ecology.

The morning's specimens were pressed and our activities were reported. After lunch Wells and Fons decided to try to find a reported beach pool on the eastern shore. Hendricks, Thompson, and Hazlett opted for an exploration of the woods and perched dunes west of the settlement. Fons and Wells were unsuccessful in locating pools and later returned for a swim in a chilly Lake Michigan. Hazlett, Hendricks, and Thompson made their way to the perched dunes from which a fine view of the once active settlement, the anchored *Odyssey*, and North Fox Island could be seen. These three collectors also took a quick dip in the lake upon their return.

After dinner that evening, which was served aboard the *Odyssey*, the afternoon's plants were pressed and the expedition members had a relatively early bedtime.

We got an early start to North Fox the next morning. Breakfast was served aboard the ship as we motored toward the north island through an early morning fog. Our progress was hindered somewhat by the loss of the ship's radar. Upon reaching North Fox, the *Odyssey* lay off the southwest tip

Fig. 3. Hazlett, Thompson, and Hendricks after a morning's collecting on South Fox.

of the island and the *Betty S* delivered the botanical explorers to the island. Arrangements were made to meet the *Betty S* at the same spot at 4 PM. Our lunch-time destination was the Shelden House, a summer residence, about a mile north along the shore. Intense collecting was resumed as soon as we began our trek north. First the shore, then a small blowout, the island's only dune community, were explored. Later, as the fog lifted, Wells and Fons continued along the shore while Hazlett, Thompson, and Hendricks descended into the northern hardwood forest from the top of the blowout, and followed a trail to Shelden's. After lunch we wrapped the contents of our overflowing collection bags in newspaper and resumed collecting enroute to the island airstrip .25 miles to the north. The woods along the trail were moist and several species which we did not encounter on South Fox were found here. Among these was skunk cabbage (*Symplocarpus foetidus*) for which this is the only station that Thompson has found in Leelanau Co.

We next explored the mile-long airstrip and collected a number of sedges and forbs along its open wet edges while Thompson left us to explore the adjacent woods.

After exploring the airstrip, we returned to the Shelden House and again wrapped our collections in newspaper. To finish our trip to North Fox, Hazlett and Wells followed the trail south through the hardwood forest and then along the gravelly east shore. Fons and Hendricks explored the wet woods in the interior of the island. After hours of collecting while bushwacking through the interior, the two emerged on the beach on the east side of the

island. The beach consisted of large cobble, that was very difficult to traverse, so, with encouragement from biting flies, they were eventually driven back into the woods. Thompson, meanwhile, collecting in the northern hardwoods along the southeastern portion of the island, discovered a colony of striped maple. Wells and Hazlett came around the south tip of the island and met Capt. Clyburn at the appointed time. Later the rest of the expedition and our specimens were picked up at Shelden's.

Our general impression of North Fox was that it was much richer than South Fox, both in the appearence of its vegetation and the size of the canopy species. Perhaps this is in part due to different past land uses or moister soil conditions.

We headed back to South Fox and enroute planned our next activity over dinner. The island's caretaker, Keith Chappel, had been out to the island the day before and had mentioned the existence of the island's last remaining uncut forest stand, a 38 acre tract at the island's northern-most tip. Our general consensus was to put the North Fox specimens in a cool place and then use the remaining hours of daylight to go to the north end to investigate the stand.

The only available means of transportation which would carry the five of us was an old four-wheel drive GMC pick-up. Although the radiator had a pencil-sized leak, we decided to make an attempt anyway. With Fons as driver, Hazlett as navigator, and Thompson, Hendricks and Wells as passengers in the back, we urged the truck up the bumpy logging road which had been easily covered by the three-wheeler the day before. With us was an ax to remove the small tree which had previously stopped Hazlett and Thompson and, most important of all, a full 5 gallon water can. The passengers spent much of their time ducking low branches while maintaining a firm hold as the truck lurched forward. Those in the cab, meanwhile, kept an eye on the temperature gauge. Each time the needle reached the upper limits, Fons would stop the truck and, as the engine ran, pour more water into the radiator from the five gallon can which ran out just as we reached the water hole. With a new supply of coolant, we resumed our quest. At our next stop, we removed the tree which had been blocking the trail. At last the trail and our water supply came to an end.

Fons and Hendricks volunteered to retrieve more water from Lake Michigan while Wells, Thompson, and Hazlett remained behind to investigate the woods and collect more specimens. To reach the lake, Hendricks and Fons had to descend 300 feet down a steep bluff. To return they had to ascend this bluff with the full 5 gallon can of water. Daylight was waning as they returned with the water and joined the others, who had not had enough time to fully explore this area and come to any conclusions as to its lumbering history. A few more species, however, were collected at this stop. Our trip back included a brief stop at the water hole for another 5 gallons for the radiator.

While the cadets made a bonfire on the beach, the authors spent another long evening pressing and recording the plants collected that day. The cadets were able to enjoy our trip to the islands. During our stay on South Fox they had been given liberty to explore the island and many chose to hike to the

crash site of a U.S. Army Chinook helicopter which killed its six crew members in 1983. On North Fox most took the opportunity to swim at the small sandy beach on the island's west side, and a few assisted in the attempt to find the *Sunnyside,* a wrecked ore-carrying schooner.

The crew of the *Noble Odyssey* and the botanists awoke before dawn and prepared to return to Mackinaw City. Five full plant presses were set above the cabin to dry out on our way back. Our efforts over the last three days would be marked by over 125 species collected for the first time from the Fox Islands and a better knowledge of the individual floras of each island.

Among the species collected in the northern hardwoods of the Fox Islands for the first time were sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), ironwood (*Ostrya virginiana*), beech (*Fagus grandifolia*), beech drops (*Epiphagus virginiana*), intermediate wood-fern (*Dryopteris intermedia*), red baneberry (*Actaea rubra*), twin-leaved miterwort (*Mitella diphylla*), and downy yellow violet (*Viola pubescens*). On the dunes and dune borders, twinflower (*Linnaea borealis*), balsam ragwort (*Senecio pauperculus*), common juniper (*Juniperus communis*), *Ammophila breviligulata,* little bluestem (*Andropogon scoparius*), *Calamovilfa longifolia, Koeleria macrantha,* balsam poplar (*Populus balsamifera*), and grape (*Vitis riparia*) were new collections. New field species included poison ivy (*Toxicodendron radicans*), milkweed (*Asclepias syriaca*), knapweed (*Centaurea maculosa*), daisy (*Chrysanthemum leucanthemum*), dandelion (*Taraxacum officinale*), quack grass (*Agropyron repens*), black medick (*Medicago lupulina*), white sweet-clover (*Melilotus alba*), red clover (*Trifolium pratense*), white clover (*T. repens*), hairy vetch (*Vicia villosa*), bracken fern (*Pteridium aquilinum*), strawberry (*Fragaria virginiana*), and wild carrot (*Daucus carota*). Fifty-seven species were new records for plants appearing in *Michigan Flora, Part 2* (Voss 1985). Among these species were *Stellaria calycantha,* bugseed (*Corispermum hyssopifolium*), false heather (*Hudsonia tomentosa*), flowering spurge (*Euphorbia corollata*), fireweed (*Epilobium angustifolium*), knot-grass (*Polygonum aviculare*), small flowered crowfoot (*Ranunculus abortivus*), *Fragaria vesca, Salix exigua, Osmorhiza chilensis,* and great-spurred violet (*Viola selkirkii*). Pitcher's thistle was the only Michigan threatened species collected on both islands. Pumpelly's bromegrass (*Bromus pumpellianus*) and broomrape (*Orobanche fasciculata*) were collected on South Fox.

Naturally, we would have our memories. The ship had lived up to its name, and we had had a fantastic adventure. We would return to our other summer activities, and the *Odyssey* and her crew would go on to yet another mission, escorting the former presidential yacht, *Sequoia,* as part of her tour of the Great Lakes. We would dream, of course, about returning to the Fox Islands, and perhaps, plan future visits to other islands of the upper Great Lakes aboard the *Noble Odyssey, YP-587.*

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The members of the Fox Island Expedition wish to thank the crew of the *Noble Odyssey* for their hospitality and willingness to have us on board for four days. The crew for our trip

included: Commanding Officer, LCDR Luther Clyburn; Executive Officer, LT Don Wurstner; Operations Officer, LT Stuart Pilcher; Deck Officer, LTJG Leonard DeNard; Engineers, Mike Lenk, Ed Pilcher; Cook, Fidel Canteau; Dive Master, Vic Birdsell.

Great Lakes Division U.S. Naval Sea Cadets on this excursion were: E/4-Leading P. O., Todd Myers, Maurice Markowsky, Sean Ennis; E/3-Willie Grant; E/2-Sean Taylor; S. H.-James Williams; E/1-Larry Carlton; S. R.-Nathan Hall, James Lewien, Harley Scribner, Charles Weaver, David Markowsky, Antoine Weston, and Joe Weston.

We further express appreciation to Dr. Thomas M. Stevens, owner of the South Fox Island camp property and to its manager, Mr. Keith Chappel, for permission to use island facilities and to collect. We also appreciate the generosity of the Alger Shelden family for allowing us the same privileges on North Fox.

EPILOGUE

In late May 1985, I returned to the Fox Islands by light aircraft to document the spring flora. Both islands were at the peak of the season. The most exciting find on North Fox was *Calypso bulbosa* at several locations in the low cedar forest on the north side of the island. Huron tansy (*Tanacetum huronense*), a Michigan threatened species, was found on the north shore, updating a record first made by F. H. Test in 1963. South Fox was becoming more civilized. A lumber crew from Wisconsin was starting to remove veneer logs from the private land on the island. The bumpy logging roads had been widened and smoothed out for the heavy equipment used in this operation. Green spleenwort was found on cedar logs at the ends of other interdunal valleys and Huron tansy was found on the dunes of the island's west side. One surprise was skunk cabbage in the wet woods west of the airstrip.

In retrospect, I find it amazing that we covered as much area and collected as much as we did during those 2½ July days. It was truly an infectious adventure complete with serendipitous discoveries. The rapport among the investigators was excellent. Such a time could not have been improved, nor could it be repeated. It will, however, be the source of pleasant memories for a long time.

BTH

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145

THE EFFECT OF FRUIT CONDITION ON GERMINATION SUCCESS OF TWO DOGWOOD SPECIES

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In some plant species that are commonly dispersed by fruit-eating animals, germination success is higher from seeds ingested by vertebrates than from untreated seeds. For example, seeds of mayapples ingested by eastern box turtles (Rust & Roth 1981), seeds of several woody species eaten by birds (Krefting & Roe 1949), and seeds of several herb, shrub, and tree species consumed by black bears (Rogers & Applegate 1983) yielded higher germination in laboratory studies than did non-ingested seeds. Such "improved" germination is due to erosion of physical barriers by mechanical abrasion and digestive fluids. Presumably, these barriers evolved to protect seeds during passage through a disperser's gut. Although higher germination following ingestion is often assumed (e.g., Herrera & Jordano 1981; Stapanian 1982) several studies have found decreased germination from seeds ingested by birds (Krefting & Roe 1949; Livingston 1972; Salomonson 1978), even when the birds tested were the presumed dispersers.

This study examines the effect of fruit condition on germination success of two *Cornus* species. Both *Cornus amomum* Mill. (silky dogwood) and *C. racemosa* Lam. (gray dogwood) are common shrubs over much of the eastern United States and Canada (Gleason & Cronquist 1963). Both produce drupes with stones containing zero, one, or two seeds (Borowicz, unpublished data). In central Pennsylvania, fruit ripen early to mid-August and are removed by a variety of birds and mammals (Martin et al. 1951). Many fruit fall to the ground, either undamaged or with rotting pulp, and most fallen fruit are secondarily removed (Borowicz & Stephenson 1985).

Four pre-germination categories were examined in this study: (1) control: undamaged whole fruit; (2) damaged whole fruit: brown fruit in which the pulp had begun to rot; (3) naturally-stripped stones: stones stripped of pulp during handling by birds and subsequently regurgitated; (4) artificially-stripped stones: stones stripped of pulp by hand. Specifically, the questions addressed in this study are: (1) Do the two species exhibit overall differences in germination success? (2) Do seeds in stones ingested by birds exhibit higher germination than do seeds in stones covered by undamaged pulp (control)? (3) Do seeds handled by birds exhibit higher germination than do seeds cleaned of pulp by hand? (4) Do seeds in undamaged fruit exhibit higher germination than seeds in brown, damaged pulp?

METHODS

Fallen fruit were collected weekly from fruit traps under *C. amomum* and *C. racemosa* plants from early September through late October 1983. All collections were made from the same site near State College, Centre Co., Pennsylvania. Fruit were grouped by species and condition (control, brown, or naturally-stripped stone) and stored in nylon mesh bags in a protected area outdoors. For the ''artificially-stripped stones'' category, additional fruit were collected directly from plants on 9 September, cleaned of pulp, and stored in nylon mesh bags outdoors with the other fruit. This period outdoors lasted more than 60 d and constituted the first cold exposure. Before the first germination trial, ten replicates of 14 stones per replicate (or 14 fruit per replicate, in the case of control and brown categories) were blindly selected from each of the 8 bags containing species-category combinations. The whole fruit or stones were placed in moist vermiculite in glass culture dishes to simulate the poorly drained lowland site where fruit were collected.

Both *C. amomum* and *C. racemosa* exhibit double dormancy so that seeds usually do not germinate until the second spring (US Forest Service 1948). To increase the probability that seeds were given appropriate conditions for germination, the replicates were exposed to two additional cold periods. Each exposure lasted more than 60 d at 4° C and was followed by a germination trial. All trials were conducted at room temperature.

After the fourth germination trial (see below), all stones and fragments were recovered. Intact locules were opened and the contents recorded (seed or no seed). Percent germination for each replicate after three trials was determined by the following:

$$\%\ \text{germination} = \frac{(\#\text{germinations in trials } 1+2+3)}{(\#\text{germinations in trials } 1+2+3+4) + (\#\text{remaining seeds})} \cdot (100)$$

Percent germination was analyzed with the MRANK procedure of SAS (SAS Institute 1983, p. 215) which performs a generalized Friedman's test (Conover 1971).

Extremely low germination of *C. racemosa* seeds suggested that the cold periods were not sufficiently severe to break dormancy. To pursue this possibility, the stones and fruit that failed to yield seedlings were exposed to a fourth cold period followed by a fourth germination trial. Half of the replicates of each species were randomly selected for a cold treatment in a freezer at −4° C. The remaining replicates were returned to the refrigerator. This fourth cold period lasted 97 d.

Many seeds failed to germinate even after four cold periods. To examine the viability of these seeds, one to eight embryos from each replicate were removed from the endosperm, placed in 0.5% 2,3,5-tetrazolium chloride solution, and kept in the dark for 20 to 24 h at room temperature (Moore 1964). Viability of each embryo, as indicated by color development, was scored as good (=1), fair (=2), or poor/not viable (=3).

RESULTS

Peak germination occurred after the third cold period (Table 1), which was consistent with the observation that both species exhibit double dormancy (US Forest Service 1948). *Cornus amomum* seeds exhibited higher percent germination across all categories compared to *C. racemosa* ($P=0.0001$, Table 1). Overall, category significantly affected germination ($P=0.0036$) but tests within species reveal that the effect of category was limited to *C. racemosa* seeds (*C. racemosa*: $P=0.0012$, *C. amomum*: $P=0.5029$). Although *C. racemosa* seeds exhibited low germination across all categories, brown fruit and naturally-stripped stones showed lower germination success than did control (undamaged) fruit and artificially-stripped stones (Table 1).

Instead of enhancing germination success, freezing decreased it. No *C. racemosa* seeds germinated after being frozen and only 6 *C. amomum* seeds

TABLE 1. Mean % germination following trials 1, 2, and 3. Means are cumulative. (Statistical analysis was conducted on % germination after three trials.) Included are mean ± standard error (SE) and number of replicates (*n*) for each species and category.

	C. amomum mean (±SE)				*C. racemosa* mean (±SE)			
Category	1	2	3	*n*	1	2	3	*n*
Control	0.8(0.8)	6.7(1.9)	48.8(8.8)	9	0(0)	3.9(3.1)	8.4(3.1)	10
Brown	1.5(1.0)	5.0(2.3)	38.9(10.0)	9	0(0)	0(0)	0.6(0.6)	10
Naturally-stripped	1.1(1.1)	4.8(2.1)	32.2(8.1)	10	0(0)	0(0)	0(0)	10
Artificially-stripped	0(0)	5.2(2.5)	41.8(6.6)	10	0(0)	3.8(2.5)	9.0(3.7)	10

germinated, constituting less than 20% of *C. amomum* seedlings that emerged during the fourth germination trial.

The tetrazolium test for viability showed intense color development in many *C. amomum* embryos that failed to germinate, indicating that many embryos remained viable (Table 2). Most *C. racemosa* embryos were pale pink or white and therefore not viable. Even after freezing, many *C. amomum* embryos still gave strong color development whereas very few *C. racemosa* embryos produced any color at all. This difference between species in viability after refrigeration and after freezing is consistent with results from the germination trials.

DISCUSSION

Cornus amomum and *C. racemosa* are closely related species that are similar in growth form, fruit characteristics, and dispersers. However, the two species differed in overall germination success and responded differently to pre-germination condition of fruit. Neither species gave any evidence supporting the hypothesis of the evolution of physical barriers to protect seeds during passage through a vertebrate gut.

Cornus racemosa exhibited lower germination across all categories compared to *C. amomum*. One explanation for the lower performance of *C. racemosa* may be inherently lower viability, independent of the conditions of the experiment. Viability was not examined prior to the onset of the experiment so this possibility cannot be addressed. It is also possible that conditions in this study more closely matched habitat requirements of *C. amomum*. Although fruit of both species were collected from the same lowland area, *C. racemosa* is more common on well-drained sites and may yield higher germination under field conditions not mimicked in this study.

If *C. amomum* and *C. racemosa* evolved physical barriers to protect seeds during passage through a vertebrate gut, seeds in naturally-stripped stones should exhibit higher germination than seeds in untreated fruit. *Cornus amomum* seeds did not differ among categories and seeds in naturally-stripped *C. racemosa* stones failed to germinate at all, strongly arguing against the presence of protective barriers.

TABLE 2. Results of tetrazolium test for viability of seeds from each species and category. Given are mean, standard error (SE), and number of embryos sampled (*n*). Values for viability range from 1 = highly viable to 3 = dead.

	C. amomum			*C. racemosa*		
Category	mean	SE	*n*	mean	SE	*n*
NOT FROZEN						
Control	2.1	0.3	11	2.7	0.1	25
Brown	1.4	0.2	12	2.6	0.1	22
Naturally-stripped	1.9	0.3	10	2.9	0.1	26
Artificially-stripped	1.9	0.2	24	2.5	0.2	22
FROZEN						
Control	2.0	0.3	9	2.9	0.0	29
Brown	1.9	0.3	12	3.0	0.0	25
Naturally-stripped	1.5	0.3	12	3.0	0.0	24
Artificially-stripped	1.5	0.1	13	2.5	0.2	21

The difference in germination success between seeds from naturally-stripped and artificially-stripped *C. racemosa* stones was consistent with trends of *C. racemosa* noted by Krefting & Roe (1949) in a study of the effect of vertebrate ingestion on germination success. In their study, only 2% of seeds in stones fed to quail germinated compared to 35% of seeds in artificially-stripped stones. They explained the difference between treatments as being the result of mechanical abrasion or digestive acids which kill seeds or weaken stones and consequently make seeds more vulnerable to the effects of water, temperature, and microbes.

In my study, there may be an alternative explanation for the difference in germination success between seeds from artificially-stripped and from naturally-stripped *C. racemosa* stones. The fruit from which the artificially-stripped stones were taken were collected early in the season whereas most stones or fruit in all other categories were collected after that date. As a result, seeds in artificially-stripped stones may have varied less in age and may have benefitted from briefer exposure to field conditions. However, an age or exposure effect seems unlikely because seeds from artificially-stripped stones were similar in germination success to seeds from ripe fruit. The latter were collected over the same period as naturally-stripped stones.

Escape from density-dependent pathogens is one presumed advantage of seed dispersal (Howe & Smallwood 1982). Pulp of both species rots rapidly after the exocarp is punctured (Borowicz, in prep.) and this study suggests that the presence of rotting pulp leads to decreased germination of *C. racemosa* seeds. However, germination of seeds from brown fruit was no worse than that from seeds in naturally-stripped stones. Therefore, the cost of dispersal, in terms of seed germinability, appears to be similar to losses incurred by remaining beneath the plant. The advantage of dispersal most likely lies in some aspect other than germination success.

SUMMARY

Germination success of *Cornus amomum* and *C. racemosa* seeds from fruit of four catagories of fruit condition was examined. The four categories were 1) undamaged whole fruit, 2) brown (damaged) whole fruit, 3) stones stripped of pulp by birds, and 4) stones stripped of pulp by hand. *Cornus amomum* seeds yielded higher % germination across all categories. Fruit condition did not affect germination success. Germination success of *C. racemosa* seeds was low across all categories but undamaged whole fruit and artificially-stripped stones produced more seedlings than did brown fruit or naturally-stripped stones. No *C. racemosa* seeds in naturally-stripped stones germinated.

In a viability test of seeds that failed to germinate after 4 cold periods, *C. amomum* embryos were more viable than *C. racemosa* embryos, even after being frozen. No *C. racemosa* embryos from brown fruit or naturally-stripped stones were viable after freezing.

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245

SHORT-TERM DROUGHT EFFECTS ON THE ALVAR COMMUNITIES OF DRUMMOND ISLAND, MICHIGAN.

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The summer of 1983 was marked by warmer, and in some areas drier, than normal conditions throughout much of the Great Lakes and surrounding regions. Effects of this short-term drought were especially noticeable in the alvar communities on Drummond Island's "Maxton Plains". Shallow organic soils overlying dolomite bedrock in these localities allows for little soil moisture storage or retention. This, combined with the gently sloping nature of the impervious substrate which enhances runoff, makes these communities vulnerable to moisture deficits caused by even brief rainless periods during the summer months. Such effectively rainless periods during the summer of 1983 extended from mid-June through July. During this interval a total of only 44 mm of precipitation was recorded at De Tour Village (U.S. Weather Service) approximately 22 kilometers southwest of the Maxton Plains. Approximately 100 mm of rainfall normally occurs during this period (Fig. 1). Because much of the precipitation is from localized convectional systems during this period of the year, rainfall is spotty and the actual amount received on the Maxton Plains may have differed from that recorded at De Tour Village. Our observations during this time, however, clearly indicated widespread and severe moisture stress throughout the alvar communities on Drummond Is. This report describes the effects of this short-term drought on the composition of the grasslands and adjacent forest-transition zone.

THE STUDY AREA AND METHODS

Drummond Island is located approximately 1 km east of the eastern tip of Michigan's Upper Peninsula in northern Lake Huron, (46°00′ N.Lat.; 83°40′ W.Long.). The Island covers approximately 310 km^2, with extreme dimensions of ca. 32 km from east to west, and 21 km from north to south. The entire Island is underlain by dolomitic limestones of the Niagran Series; these outcrop at scattered points throughout but are largely free of glacial and other surficial deposits over extensive areas of the northern portion known as the Maxton Plains. Extensive till-free areas of this northern reach of the Island are dominated by an herbaceous vegetation occurring as various sized patches and surrounded by coniferous (boreal) forest. Such bare limestone communities have been referred to as "alvar communities" or "alvars" (Catling et al. 1975; Konigsson 1968; Petterson 1965; Stephenson 1983). The herb-dominated alvars on the Maxton Plains occur as two more or less distinct phases; those with extensive bare rock exposures are herein referred to as "pavement" sites (Fig. 2), and those with essentially continuous vegetation cover are referred to as "grassland" sites. The zone of encroachment by the surrounding boreal forest vegetation is referred to as the "transition zone". For a more complete description of the Maxton Plains vegetation, see Stephenson (1983).

In conjunction with studies started in 1981 by one of us (SNS), permanent sample transects were established in two of the pavement sites D_1 and D_2 [*loc. cit*]) and in three grassland

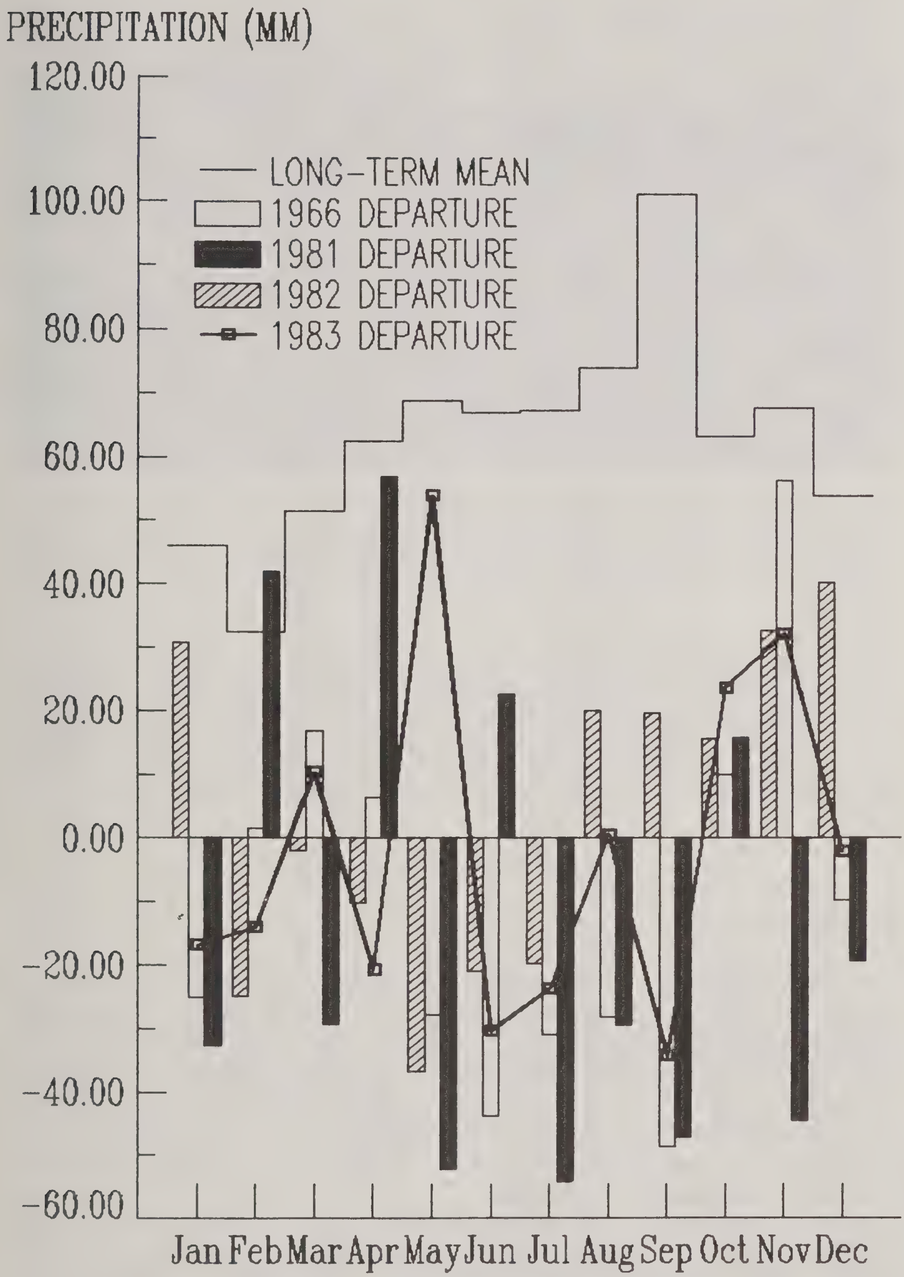

Fig. 1. Monthly precipitation values, De Tour Village, Michigan. The stepped line represents the mean monthly precipitation values for the period 1964–1983; the 3 bars in monthly sets and the heavy line represent the departure from the long-term mean for the years indicated.

Fig. 2. Mid-July view of a ''pavement'' site on Maxton Plains, Drummond Island, Michigan. The vegetation of this alvar is a mixture of prairie dropseed, *Carex scirpoidea*, and low shrubs and herbaceous broad-leaved species. The shrub in the foreground is *Prunus pumila*. The view is upslope with aspen-juniper transition and conifer forest in the background.

sites (Camp, Geum, and Aspen [*loc. cit*]). These sample sites were resampled during the spring-early summer of 1984 to examine the effects of the 1983 drought. Methods are detailed in Stephenson (1983). In addition, population structure data for several species were collected in 1982 (SNS, unpubl. data) on permanently marked transects or quadrats. Additional population studies were initiated during 1983, primarily to determine survivorship patterns among woody taxa in transition zone sites. These population studies were continued during 1984.

DROUGHT EFFECTS

Weather and Soils.

From the standpoint of annual mean precipitation values 1983 was not an unusually dry year; mean temperature, however, was about 1° C greater than the mean annual temperature for the 20 year interval from 1964 through 1983. The mean maximum temperatures for the months June–September ranged from 2° to 3° C above the long term normal (Fig. 3). Sporadic growing season rainfall combined with higher than normal temperatures resulted in severe soil moisture depletion, an effect which is especially pronounced in the shallow alvar soils.

Soil temperature measurements made during the interval of July 13–15, 1983 give some indication of the conditions during the mid-summer. Mid-afternoon air temperatures (1500–1645 hrs) on these dates ranged from 31°C to 35°C. Soil temperatures at the same time ranged from 41°C (106°F) in the soil surface (sensor imbedded in the surface litter < 1 cm), to 28°C at 3–5 cm in a representative grassland site. In similar positions in the adjacent forest-

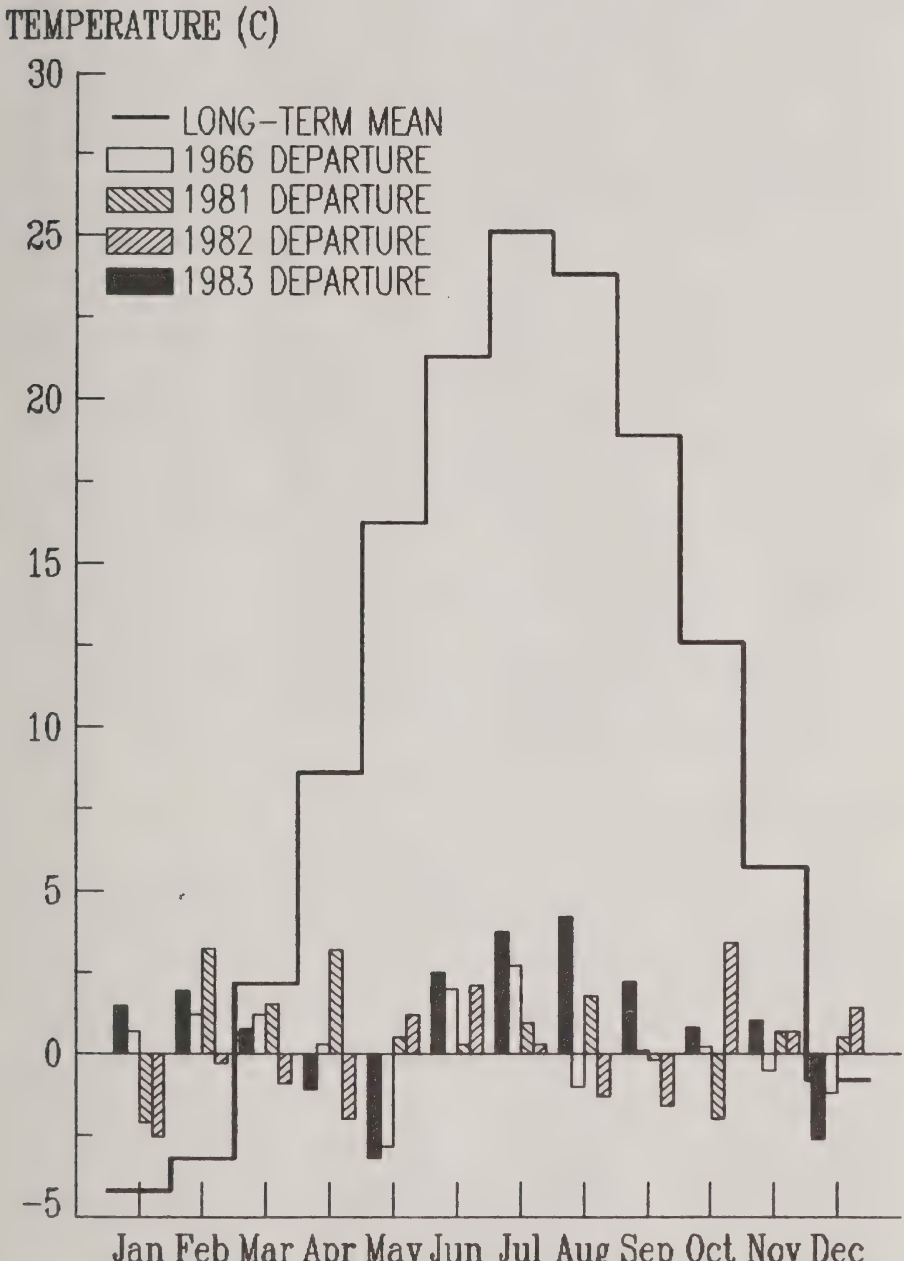

Fig. 3. Monthly mean maximum temperatures, De Tour Village, Michigan. Interpretation same as in Fig. 1.

transition, soil temperatures were 28°C and 20°C. The most extreme condition noted at this time was in the surface rubble in frost boils or catchment "pannes", where temperatures of 48° C were recorded.

Moisture content of soil samples taken at this time were 13.7 ± 1.85% (mean ± 1 s_x) in the upper 5 cm., and 5.5 ± 1.0% in the lower 5–8 cm. In transition zone sites moisture contents were somewhat greater e.g., 19.4 ± 0.6% and 8.4 ± 1.0% in upper and lower soil levels respectively in the transition edge under aspen, and 26.8 ± 1.1% (upper level) in juniper-soapberry (*Shepherdia*) transition. In the adjacent mature forest soil moistures were 30.7 ± 4.8% and 14.7 ± 0.9% in the corresponding levels. In comparison, soil samples obtained on August 29, 1983, 7 days after a 28 mm. rain, surface soil moistures were 82 ± 8.7%, 91.8 ± 6.5% and 77.3 ± 19.7% in the same grassland, transition, and forest sites respectively. The soils at this time appeared to be at or below field capacity.

Dry periods also occurred in 1980 and 1981; however, no drought effects were noted comparable to those following the 1983 growing season. An examination of the De Tour weather data revealed below normal precipitation for the June–September period for both years. This period normally receives approximately 40% of the annual total; in 1980 precipitation for the period was 29%, for 1981, 25.4% and for 1983, 21.3%. Mean maximum temperature departures for this same period were, however, −0.9° C and −0.65° C for 1980 and 1981 respectively, whereas, for 1983 the departure was +1.95°. Consequently, the above normal temperatures observed during 1983 were apparently the key to the unusually droughty conditions observed that year. The intervening year, 1982, for comparison, was near normal for precipitation during the growing season (38.7%, but well below normal temperaturewise (−2.35° C).[1]

Plant populations and communities

In 1983 the early spring phenophase in the alvar communities began normally relative to observations made during the previous two seasons, although emergence and development of the earliest flowering species may have been delayed by cool and wet conditions (especially in May). By late June, however, symptoms of moisture stress could be seen in many of the herbaceous taxa by mid-day, and by late July many of the small junipers and spruces in the grasslands and transition zones were yellowing or dropping needles. As the season progressed, the grassland dominant, prairie dropseed (*Sporobolus heterolepis*) failed to develop over large areas. Substantial greening occurred only in strips overlying joints in the bedrock. Early developing perennial broad-leaved herbs such as prairie smoke (*Geum triflorum*) and prairie buttercup (*Ranunculus fascicularis*) died to ground surface.

[1]It is notable that for the period from 1964–1983 there was no significant correlation between mean annual temperature and mean annual precipitation, nor between mean monthly maximum temperatures and monthly precipitation. This indicates that the coincidence of above normal temperatures and below normal precipitation, such as observed during 1983, is largely fortuitous.

Most of the summer perennials were absent or were active only in the edges of catchments and over bedrock jointing structures. The general aspect was that of the late summer Palouse grassland where summer drought is the norm. By mid-September regeneration was evident in some of the late season taxa, and the overall aspect of the grasslands was green at the time of the last 1983 field visit by PH.

Perhaps the most conspicuous consequence of the dry summer was a mass seedling emergence of *Geranium carolinianum* and *G. bicknellii.* Although present in small numbers each year, mostly in pavement sites, these species were abundant (up to 400 m^{-2}) in all open sites, and found in moderate numbers in transition zones.

The full impact of the 1983 drought on the alvar communities was not evident until the following season. For some species it was reflected in changes in population structure. For other species it was the appearance in localities or communities in which they had not been recorded in previous years observations or sample results. Three species of particular interest, *Carex scirpoidea,* prairie-smoke, and prairie dropseed underwent marked changes in population structure and abundance.

Numbers of plants of the dioecious sedge, *Carex scirpoidea,* declined 42% from 1981 to 1984 at the pavement sites and 9% at the Geum site (Table 1). In 1981 there were few non-reproductive plants at either site; however, in 1984 30.5% of the plants in the pavement sites and 59% in the grassland (Geum) site did not flower. At both sites there was a significant shift toward larger size classes (basal diameter of clones = plants) in both sexes (Fig 4). Sex ratios, male biased in both populations (though significantly only at D_1, $Chi^2 = 8.81$, $P < .001$) in 1981, remained male biased in the pavement sites with about the same ratio [m/f = 1.96 (1981) vs. 1.84 (1984)]. In the grassland site the ratio became female biased, though not significantly [m/f = 1.3 (1982) vs. 0.51 (1984)]. Even though mortality was greater in populations in the pavement sites, a larger proportion of the survivors reproduced, and in about the same male/female proportions as in previous years. Most of the surviving plants were established in or above joints in the bed rock, whereas those killed by the drought were mostly in marginal sites. It was not immediately apparent why flowering in male plants was depressed more than females in the grassland site.

Prairie dropseed, the dominant species in both pavement and grassland sites, declined at D_1 from 99 to 44 plants (clones) encountered on the same transects on which *Carex scirpoidea* was sampled. Unlike the *Carex* however, there was no shift in size class structure of the dropseed population, suggesting that mortality was random relative to plant (clone) size (age).

Compared to that in 1982 and 1983, flowering in prairie smoke was greatly reduced in 1984. Fig. 5 illustrates the population structure at the two sample dates. In 1982 the population was composed primarily of reproductive and large non-reproductive rosettes; in contrast the post-drought population, after a 53% decline in total numbers, was composed primarily of small ("juvenile") rosettes, many of which appeared to be seedlings of the year. Although the total number of flowering rosettes was reduced, flowering vigor appeared to be unaffected; no significant differences were found in the

TABLE 1. Relative cover (%) of the most abundant taxa in two pavement and three grassland sites for the growing seasons before and after the 1983 drought year. Values are means; * indicates a significant difference between years at P ≤ .05; determined by "t" test on arcsin transformed data.

SPECIES	SITE 1981	D-1 1984	SITE 1981	D-2 1984	CAMP D 1982	CAMP D 1984	GEUM 1982	GEUM 1984	ASPEN 1982	ASPEN 1984
Sporobolus heterolepis	50	40*	48	40	36	37	72	42*	45	63*
Schizachyrium scoparium	6	10	3	2	0	0	5	<1	32	6*
Geum triflorum	0	0	<1	0	<1	0	5	<1	0	0
Carex scirpoidea	24	21	19	15	<1	0	1	0	<1	<1
Senecio pauperculus	2	1.5	1	1	7	12.5*	6	14.1*	2	4
Cerastium arvense	<1	0	<1	0	<1	0	<1	0	<1	0
Comandra richardsiana	2	0	0	0	<1	<1	0	0	<1	0
Fragaria virginana	<1	0	<1	0	20	3*	<1	0	0	0
Agropyron caninum	<1	0	<1	0	<1	1.5	0	1	<1	<1
Eleocharis compressa	<1	0	<1	0	33	33	<1	22*	0	0
Ranunculus fascicularis	<1	0	<1	0	<1	<1	<1	<1	<1	<1
Poa compressa	<1	<1	<1	<1	<1	7*	2	6*	<1	2
Hieracium piloselloides	4	0*	1	<1*	4	1*	4	1*	0	0
Artemisia caudata	0	<1	0	5*	0	0	0	0	0	<1
Campanula rotundifolia	0	2	0	1	0	0	0	0	0	<1
Trichostema brachiatum	0	<1	0	5	0	0	0	0	0	0
Arenaria stricta	<1	<1	<1	2*	0	<1	<1	7*	<1	6*
Scutellaria parvula	<1	<1	0	0	0	3	0	1.5	0	<1
Geranium bicknellii	0	0	0	0	0	<1	0	<1	0	<1
G. carolinianum	0	0	0	0	0	5.5	0	1	0	1
Ambrosia artemisiifolia	0	<1	0	0	0	<1	0	1	0	3
TOTAL COVER	56	23*	45	18*	75	91*	88	83	68	83*
TOTAL SPECIES IN SAMPLE	28	16	27	13	15	22	18	20	21	22

Species occurring in samples at low frequencies: *Achillea lanulosa, Agrostis scabra, Anemone multifida, A. cylindrica, Antennaria* sp. *Aquilegia canadensis, Arabis hirsuta, A. lyrata, Arenaria serpyllifolia, Aster ptarmicoides, A.* sp., *Barbarea vulgaris, Botrychium* cf. *simplex, Bromus kalmii, Cardamine parviflora, Carex aurea, C.* cf. *crawei, C. eburnea, C. merritt-fernaldii, C. richardsonii, Castilleja coccinea, Cerastium fontanum, Cirsium hillii, Danthonia spicata, Deschampsia caespitosa, Dichanthelium acuminatum, Erucastrum gallicum, Epilobium ciliatum, Festuca* cf. *ovina, Habenaria unalascensis, Hypericum perforatum, Juncus dudleyi, Lathyrus palustris, Lilium philadelphicum, Panicum capillare, Phleum pratense, Poa pratensis, Potentilla norwegica, Prunella vulgaris, Saxifraga virginiana, Silene antirrhina, Sisyrinchium montanum, Solidago nemoralis, Solidago* sp., *Taraxacum officinale, Tragopogon* sp., *Trifolium repens, Trisetum spicatum, Zygadenus glaucus.*

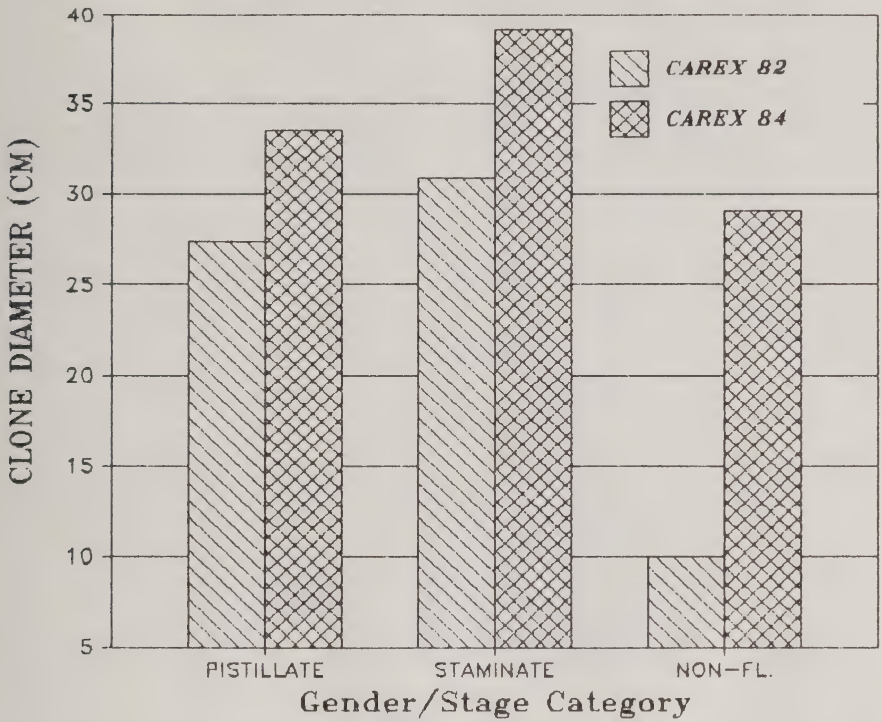

Fig. 4. Diameters of *Carex scirpoidea* clones at the Geum Site for the 1982 and 1984 growing seasons, illustrating the change in size class structure within the population.

frequencies of scapes bearing 1, 2 or 3 fully developed seed heads in the two years (K-S D_{MAX} = .074, Chi^2 = .69, P > .1).

Mortality among small size-class woody invaders ranged from nearly complete in open grassland and transition edges, to ca. 20% in one representative transition zone. White spruce (*Picea glauca*) and spreading juniper (*Juniperus communis*) were largely eliminated in many sites. Soapberry was less affected than the evergreen species, although mortalities of up to 60% were noted in one population established beneath aspen (*Populus tremuloides*) near the Geum site. Aspen is the most important of the woody invaders. Of 100 sprouts at the edge of the invading ''front'' tagged during 1982 at the Camp site, all were killed to ground level or showed signs of drought damage by September 1983. At the end of August 1984, only 34% of the original stems were either active or had been replaced by a basal sprout.

Vegetation cover values for 5 of the upland communities sampled in 1981 or 1982, prior to the 1983 drought, and again during the 1984 growing season are shown in Table 1. The two pavement sites experienced the greatest change, with a reduction in total cover and number of species on the sample transects. Most of the reduction resulted from the disappearance of perennial species from marginal microsites. The increase or new appearance of some species such as *Trichostema brachiatum, Arenaria stricta, Scutellar-*

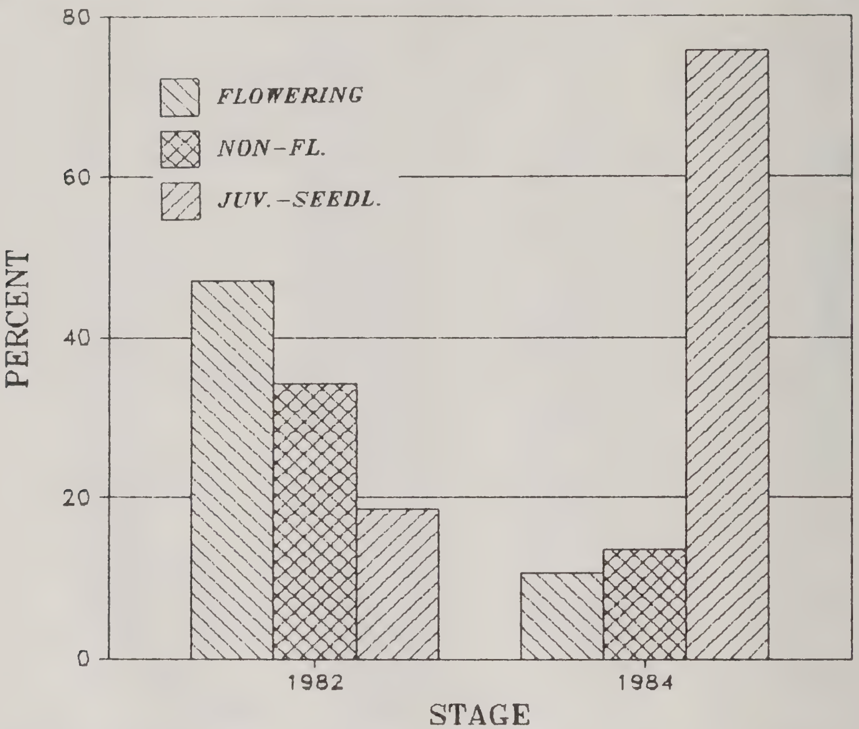

Fig. 5. Population stage structure of *Geum triflorum* for the years 1982 and 1984.

ia parvula, Artemisia caudata, Campanula rotundifolia, Erucastrum gallicum and *Arabis hirsuta,* although conspicuous, was insufficient to compensate for the cover loss by the dominants.

In the three grassland sites the response of individual species varied with the site; both significant increases and decreases were noted in the dominant prairie dropseed, and total cover increased significantly in the Camp and Aspen sites. Only in the Geum site, where prairie dropseed was strongly dominant prior to the drought did this species decrease in cover. In all cases a substantial contribution to the total cover was made by subordinate or newly appearing taxa; these are listed at the end of Table 1. Subsequent to the sample period (July), several species became conspicuous in and near the sample sites. Two of these, *Spiranthes romanzoffiana* and *S. lacera,* while conspicuous were not numerically abundant. However, their appearance in this upland grassland was surprising. The annual *Sporobolus vaginiflorus* was also more widespread and abundant than had been observed in previous years. Conspicuous by their near absence during the early and mid-season phenophases were such species as *Cerastium arvense, Castilleja coccinea,* and *Ranunculus fascicularis.* Numerous seedlings and/or rosettes of these species were observed in early September, indicating only a temporary reduction in their numbers.

DISCUSSION

Aside from the importance accruing from their richness in plants demonstrably rare in Michigan, the Maxton Plains grasslands and pavement communities represent an unique natural laboratory. Central to questions relating to the composition and future of these alvar communities is, ''What forces are controlling the species composition in the alvar grasslands, and to what extent does encroachment by forest represent a threat to their continued existence?'' The drought year of 1983 provided an opportunity to probe some of these questions by applying an experimental treatment beyond any experimentor's means, *viz* severe moisture stress. Moreover, there is little reason to suspect that this event possessed hidden dimensions that so often confound the efforts of field oriented experimentalists. It simply represents the ''brute force'' of nature. A singular drawback is the lack of a control; consequently the observed responses may simply be fortuitous correlates.

On inspection at the height of the drought, the perennial species appeared to have been severely damaged, and indeed widespread mortality did occur. By the middle of the 1984 growing season, however, it was evident that the dominants such as prairie dropseed and *Carex scirpoidea* were growing vigorously where they survived. The generally greater mortality in the dropseed, as compared to *Carex* in sites where both were major components, perhaps results from differences in their physiology; the C_3 *Carex* had for the most part completed its reproductive cycle prior to the onset of the drought in 1983, whereas the entire C_4 dropseed's life cycle was encompassed by the drought period. Consequently there was little opportunity for replacement of reserves in those plants of the latter species growing in the least favorable sites.

The immediate effect of drought induced mortality on the community was to fragment the areal cover of perennial species; in addition, there appeared to be greater frost heaving during the winter of 1983–84 in the grassland sites than had been observed previously. The net effect was to provide more area suitable for the colonization or emergence of annual and other caespitose taxa, and vegetative expansion of rhizomatous perennials. Many of the former must have emerged from soil-stored seed pools or suppressed vegetative organs, as they were either rare or altogether absent from grassland sites during the two previous seasons. Long-term persistence of seeds in the soil is known to be important for the maintenance of many species (Osting & Humphreys 1940; Went 1948; and others). The most conspicuous of these ''newly appearing'' species were two geraniums. Both have relatively large seeds (*G. carolinianum*, 5.8 mg and *G. bicknellii*, 1.4 mg) that are relatively unspecialized for dispersal (they are flipped a short distance by the maturing fruiting structure). Their appearance in large numbers suggests that a substantial seed pool exists throughout the grasslands and that some drought associated stimulus promoted germination. *G. bicknellii* germination has been noted following fire (Ahlgren 1979; Ohmann & Grigal 1979; Abrams & Dickmann 1984) in jack pine forest. The latter authors suggest heating as the releasing physical factor, however, soil temperatures in the grassland probably were substantially less than the 90° C which they

observed to elicit the most marked germination response. Other species appeared to emerge primarily in newly created open microsites and in frost boils, notably such introduced ruderals as yellow rocket and dandelion, as well as native species. Since ruderals constituted a trivial proportion of the total cover prior to the drought it seems unlikely that they will persist or increase. One exception is the hawkweed (*Hieracium piloselloides*) which appears to be extremely well adapted to this community. It is notable that it (reported as *H. pratense*) is also a common component of Scandinavian alvar communities (Petterson 1965). Most of the native species will likewise probably assume pre-drought population levels, persisting as scattered individuals in disturbance sites or in the soil-stored seed bank. These species were well represented as rosettes or seedlings throughout the grasslands by early September 1984, suggesting an increase in importance in the immediate future. However, seedling densities were far greater than those observed during 1981 and 1982. Thus, such short-term drought episodes are probably of major importance in the maintenance of species diversity in these communities. In the absence of this type of destabilizing influence the robust perennial gramminoids are demonstrably capable of nearly exclusive dominance. Drought, therefore, replaces other elements of disturbance, such as that caused by burrowing or fossorial mammals, common to some other grasslands (Platt 1975), but notably absent on the alvars.

The fate of woody invading taxa was clearly established. Few individuals survived in the open grassland, but where they did, it was usually obvious that they were aligned along joint structures or established in association with other subsurface discontinuities. Prior to 1983, spreading junipers were present throughout the grassland as well as in the transition zones in age classes ranging upward from seedlings of the year; spruce seedlings, however, were much less common, the predominant age class in transition zone populations at the Geum and Camp sites ranging between 14–16 years (= ring counts at stem bases) (Stephenson 1983). This age group coincides closely with the last occurrence (1966) of growing season climatic conditions similar to those observed in 1983 (Figs. 1 & 2). This suggests that the transition zones may oscillate under the control of short term drought. Many of the surviving small spruces, and most of the larger size classes in older portions of the transition zone and mature forest produced a heavy cone and seed crop in 1984. Such heavy cone production following above average temperatures and/or short term drought has been observed elsewhere (Smith 1982) and was also observed in the southern Lower Peninsula in 1984. Coupled with the drought related changes in the grassland community structure and the resultant increase in open microsites, this heavy seed crop may pressage a renewed invasion by conifers.

SUMMARY

Alvar communities on the Maxton Plains, Drummond Island, Michigan were studied before and after the growing season drought period of 1983. Among the rare and threatened species found on the alvars, some declined while others increased; others displayed changes in population structure suggestive of rejuvenation. Mortality among dominant species ranged to nearly 60 percent in some sites, and to 100 percent among primary woody invaders. The

appearance of species previously not seen on the alvars and the increase of those previously at low population levels suggests that short term droughts may be important in maintaining diversity in these communities. Mass mortality among the woody invaders, leading to a recession of transition zone margins, suggests that forest encroachment into the grassland and pavement sites does not pose an immediate threat to the alvar communities. The near "normal" 1984 growing season brought renewed vigor to surviving populations throughout the alvars.

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A STUDY OF RED CEDAR NATURAL AREA. I. HISTORICAL BACKGROUND AND DESCRIPTION OF THE VEGETATION

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The Red Cedar Natural Area is located on the campus of Michigan State University, East Lansing, Michigan at T4N, R2W, section 13, the south half of the SW ¼; section 14, the south half of the SE ¼; and section 23, the north half of the NE ¼. The area is bordered on the north and west by the Red

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Cedar River. The eastern portion of the woodlot is bordered by Kalamazoo Street on the south and the western portion lies adjacent to university housing. As defined by Campus Parks and Planning, there is a total of 76 acres in the natural area. Of this, 46.7 acres are wooded with 13.9 acres occurring north of Kalamazoo Street and 32.8 acres to the south. The remainder of the area, 29.3 acres, is open and mostly located in the southernmost portion of the designated natural area. Some of the open area immediately south of the woods is used as a nursery and hardly seems to fit any definition of a "natural area," so it has not been included in this study. The open area south of the nursery supported an advanced old field vegetation and was initially included in this study. However, in the spring of 1975 this area was plowed and divided into garden plots, so it also has been removed from consideration as a natural area. Thus, of the 76 acres officially comprising the Red Cedar Natural Area, only approximately 50 acres supports a natural vegetation (Figure 1).

HISTORICAL BACKGROUND

The Red Cedar Natural Area has been subjected to many disturbances which have greatly affected the vegetation, as is easily seen by a review of the recent history of the area. The first major disturbance probably occurred in 1934 when the Kalamazoo Street bridge was constructed over the Red Cedar River. In 1940, a section of the river south of the bridge was channelized, leaving the old oxbow as a permanent body of water (Pogodzinski 1974) (Figure 1).

In the past the Forestry Department at Michigan State University has played an active role in maintaining and planting some sections of the Red Cedar woodlot. In the fall of 1942 (Bowman 1942) the Forestry Department began an extensive planting program. Plantation areas were initially planted with white pine (*Pinus strobus* L.), red pine (*Pinus resinosa* Ait.), jack pine (*Pinus banksiana* Lamb.), and ponderosa pine (*Pinus ponderosa* Dougl.). One year later 50 percent of the seedlings had died. More planting was done using Scotch pine (*Pinus sylvestris* L.) as well as red, white and ponderosa pine. Additional species that were planted by the Forestry Department are as follows (Bowman 1943): Douglas fir [*Pseudotsuga menzeisii* (Mirb.) Franco], tulip poplar (*Liriodendron tulipifera* L.), black locust (*Robinia pseudoacacia* L.), black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), Norway spruce (*Picea abies* Karst.), balsam fir (*Abies balsamea* Mill.), and black spruce (*Picea mariana* BSP.). Fire destroyed parts of the plantation plantings twice, during 1944 (Bowman 1944). In 1948–1949 forestry students completed a silviculture study of the woods and determined the dominant woody species to be ash, elm, and maple. Since then, Dutch elm disease has almost eliminated American elm from the woodlot. In 1963 dead elm trees were felled by the Grounds Department of Michigan State University and removed from the area. Today the only obvious remnant of the planting efforts of the Forestry Department in the 1940's is the pine plantation north of Kalamazoo Street. This consists mostly of *Pinus ponderosa* with occasional *P. banksiana* and *P. sylvestris*.

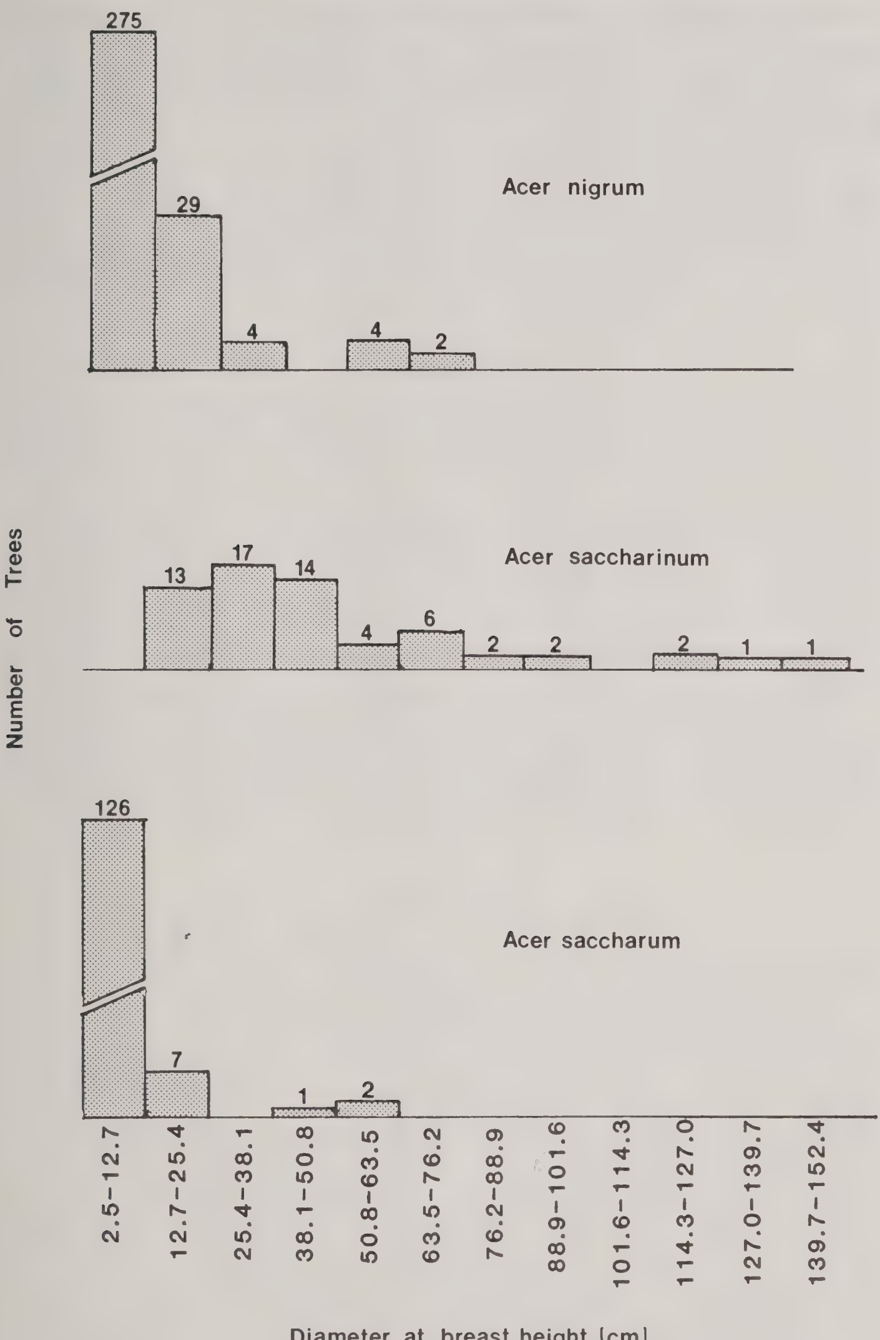

Fig. 1. Map of the Red Cedar Natural Area.

Further disturbance of the vegetation occurred when Consumers Power Company put a power line through the natural area. The exact date of this is uncertain, but the date stamped on the poles is 1954. These poles are usually used within a year of the date affixed to them, so the power line cut through the area was probably made in 1954 or 1955.

In 1969 a sewerline was installed through the area, resulting in two 20–50 foot wide swaths being cut through the length of the woodlot. This is the largest disturbance which has occurred in the area.

No efforts were made to restore the woodland in either instance of cutting so the disturbed areas have been left to re-vegetate naturally.

METHODS

Since the Red Cedar Natural Area has been subject to the numerous previously mentioned disturbances, an effort was made to gather sample data from the least disturbed portion of the woods. This restricted the sample area to relatively small portions of the woodlot north and south of Kalamazoo Street which had little or no indication of planting by the MSU Forestry Department and which had an essentially closed canopy of mature trees.

The point-quarter system (Cottam & Curtis 1956) was used for sampling trees with a dbh (diameter at breast height) of 2.5 cm. or greater along transect lines laid parallel to Kalamazoo Street. The first line was placed 30 meters south of the road, with subsequent lines spaced at 20 meter intervals from the initial transect. Two parallel transects were taken in the woods north of Kalamazoo Street. Two hundred sixteen points were sampled along 10 transects. Importance values were calculated by taking the mean ($\bar{x}$) of the relative values of density, dominance, and frequency.

Along the same transect lines the plot method (Cox 1976) was used to sample the fall and spring herbaceous vegetation of the woodlot. Fifty points were sampled in the fall and 50 in the spring using 0.25 m^2 plots. Percent cover was estimated for each species occurring within each sample plot. Importance values were calculated by taking the mean ($\bar{x}$) of the relative values of dominance and frequency. The placement of all points on the transects in both the point-quarter and plot sampling was determined using a random numbers table (Brower & Zar 1977).

RESULTS

The most important woody species in the Red Cedar Natural Area are *Acer nigrum* Michx.f., *A. saccharinum* L. and *A. saccharum* Marsh. (Table 1). *Acer nigrum* and *A. saccharum* are the most frequent trees in the woods although generally of much smaller dbh than *A. saccharinum* (Figure 2). Most of the trees of *A. saccharinum* encountered were large individuals; therefore, they comprise a large portion of the canopy within the woodlot. Other upper story species commonly encountered in the area include *Celtis occidentalis* L. and *Acer negundo* L. *Fagus grandifolia* Ehrh. can be found on higher ground within the area. *Quercus bicolor* Willd. and Q. *macrocarpa* Michx., *Prunus serotina* Ehrh., *Fraxinus pensylvanica* Marsh., *F. americana*, and *Tilia americana* L. are found scattered throughout the woods. The most important understory trees are *Zanthoxylum americanum* Mill. and *Cornus alternifolia* L. These species are especially dense where there are large breaks or open spaces in the canopy; however, they are also widespread throughout the woods. Toward the edges of the woods *Prunus virginiana* L. is a major understory component. Individuals of *Prunus virginiana* are usually 5 cm. or less in dbh. *Lindera benzoin* (L.) Blume and *Staphylea trifolia* L.

are more common in low areas and along the edges of the numerous vernal pools found within the woodlot.

Of the campus woodlots previously studied, Sanford Natural Area (Beaman 1970a, b) has a species composition more similar to the Red Cedar area than Baker Woodlot (Beach & Stevens 1979, 1980). This similarity is to be expected due to the fact that portions of Sanford lie on the floodplain of the Red Cedar River and support such common lowland species as *Acer saccharinum* and *Lindera benzoin*. *Acer saccharinum* has nearly the same importance in Sanford as it does in Red Cedar woodlot. Baker Woodlot, however, is not located near the river and, although it contains several ponds and low damp areas, *A. saccharinum* is only occasionally found in the wet sites there (Stevens & Beach 1980). *Acer nigrum*, an important component of the Red Cedar area, is far more important in Sanford than in Baker Woodlot. However, Sanford and Red Cedar differ markedly in the amount of disturbance found in each. Species typical of disturbed sites which are numerous in the Red Cedar area but not in Sanford include *Acer negundo* and *Celtis occidentalis*.

The results of the fall sample of the herbaceous vegetation of the Red Cedar Natural Area also indicate the disturbed nature of the area (Table 2). The high importance value of *Toxicodendron radicans* L. indicates its abundance in the woodlot. The importance of *Hydrophyllum* in this sample is due to young shoots sprouting during a warm spell after a frost. In the fall almost 80 percent of the vegetative cover is composed of *Asarum canadense* L., *Toxicodendron radicans*, and *Viola canadensis* L. In the spring the herbaceous cover is primarily composed of *Dentaria laciniata* Muhl., *Isopyrum biternatum* (Raf.) T. & G., *Geranium maculatum* L. and *Erythronium americanum* Ker. (Table 3). *Isopyrum biternatum*, which is abundant in the

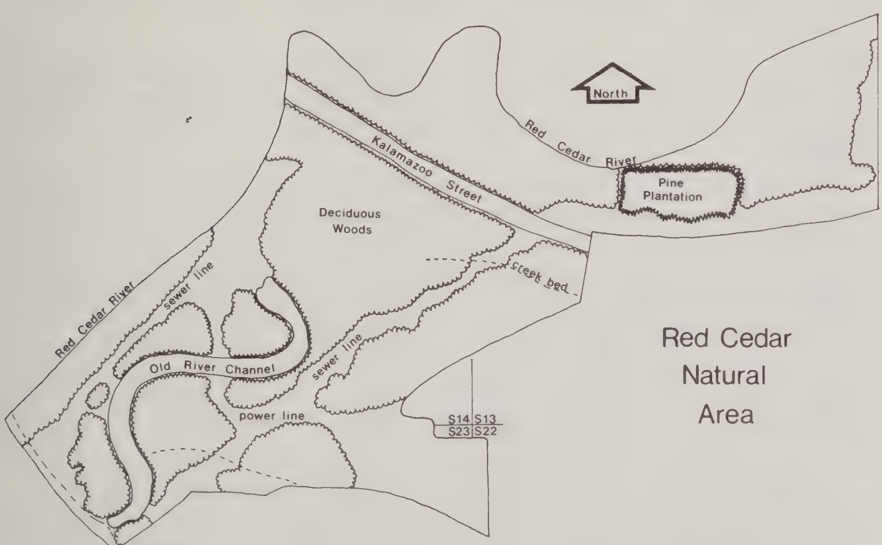

Fig. 2. Size class distribution of *Acer nigrum*, *A. saccharum* and *A. saccharinum* sampled in Red Cedar Natural Area.

TABLE 1. Results of the point-quarter sample of the woody vegetation of Red Cedar Natural Area.

Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Acer nigrum Michx.f.	35.9	9.9	26.4	24.1
Acer saccharinum L.	7.4	45.1	5.9	19.5
Acer saccharum Marsh.	15.7	3.6	15.0	11.4
Celtis occidentalis L.	9.1	7.1	10.5	8.9
Acer negundo L.	6.6	2.3	7.8	5.6
Populus deltoides Marsh.	0.4	10.4	0.5	3.8
Fagus grandifolia Ehrh.	1.9	5.1	2.5	3.2
Platanus occidentalis L.	0.8	6.6	1.2	2.7
Zanthoxylum americanum Mill.	3.1	0.9	3.2	2.4
Fraxinus pensylvanica Marsh.	1.9	2.4	2.6	2.3
Cornus alternifolia L.	2.7	0.1	3.5	2.1
Lindera benzoin (L.) Blume	2.4	0.7	2.9	2.1
Crataegus sp.	1.9	0.4	2.9	1.7
Prunus virginiana L.	2.2	0.1	2.6	1.6
Fraxinus americana L.	0.6	3.0	0.9	1.5
Prunus serotina Ehrh.	1.4	1.1	1.9	1.5
Staphylea trifolia L.	1.9	0.0	2.5	1.5
Ulmus americana L.	1.2	0.2	1.8	1.1
Quercus macrocarpa Michx.	0.5	1.5	0.7	0.9
Quercus bicolor Willd.	0.5	0.5	0.9	0.6
Rhamnus frangula L.	0.5	0.2	0.7	0.5
Acer rubrum L.	0.5	0.1	0.7	0.4
Carpinus caroliniana Walt.	0.5	0.1	0.7	0.4
Ulmus rubra Muhl.	0.4	0.2	0.5	0.4
Rhamnus catharticus L.	0.2	0.1	0.4	0.2
Tilia americana L.	0.1	0.2	0.2	0.1
Viburnum lentago L.	0.1	0.0	0.2	0.1

Red Cedar area, is infrequent in Sanford Woodlot and not reported from Baker Woodlot. *Dicentra canadensis* (Goldie) Walp. and *D. cucullaria* (L.) Bernh. are found in Red Cedar and in Sanford but do not occur in Baker Woodlot.

In addition to the deciduous woods and its herbaceous flora, other habitats within the Red Cedar Natural Area add to the diversity of the species found there. The old river channel and the numerous vernal pools provide habitats for aquatic and wetland species. Submerged aquatics such as *Elodea canadensis* Michx. and *Potamogeton* spp. are found in the old river channel which contains water all year. Emergent aquatics such as *Sagittaria cuneata* Sheldon and *Alisma plantago-aquatica* L. can be found in the shallower southern end of the channel. Typical vegetation in and around the vernal pools includes: *Cephalanthus occidentalis* L., *Pilea pumila* (L.) Gray, *Boehmeria cylindrica* (L.) Sw., and *Lysimachia nummularia* L.

Disturbed areas surround and dissect the wooded portions of the Red Cedar tract. These areas are primarily successional in nature and support numerous species typical of old fields. Some of the more common species are *Solidago nemoralis* Ait., *S. gigantea* Ait., *Aster novae-angliae* L., *Phleum pratense* L. and many other members of Asteraceae and Poaceae. *Populus*

TABLE 2. Results of the plot sample of the fall herbaceous vegetation of Red Cedar Natural Area, November, 1976.

Species	Relative Dominance	Relative Frequency	Importance Value
Asarum canadense L.	41.7	25.0	33.4
Toxicodendron radicans L.	20.5	19.7	20.1
Viola canadensis L.	16.0	21.1	18.5
Hydrophyllum spp.	1.7	13.2	7.4
Euonymus obovatus Nutt.	2.9	5.3	4.1
Geranium maculatum L.	1.9	5.3	3.6
Viola cf. *sororia* Willd.	1.2	5.3	3.2
Boehmeria cylindrica (L.) Sw.	4.5	1.3	2.9
Ribes americanum Mill.	2.9	2.6	2.7
Geum canadense Jacq.	1.7	2.6	2.2
Lindera benzoin (L.) Blume	0.4	2.6	1.5
Laportea canadensis (L.) Wedd.	1.7	1.3	1.5
Aster sp.	1.5	1.3	1.4
Phalaris arundinacea L.	0.9	1.3	1.1
Circaea quadrisulcata (Maxim.) Franch & Sav.	0.5	1.3	0.9
Acer negundo L.	0.1	1.3	0.7
Fraxinus cf. *americana* L.	0.1	1.3	0.7
Prunus virginiana L.	0.1	1.3	0.7

TABLE 3. Results of the plot sample of the spring herbaceous vegetation of Red Cedar Natural Area, April, 1977.

Species	Relative Dominance	Relative Frequency	Importance Value
Dentaria laciniata Muhl.	20.8	16.8	18.8
Isopyrum biternatum (Raf.) T. & G.	19.5	15.4	17.5
Geranium maculatum L.	13.9	12.6	13.3
Erythronium americanum Ker.	12.8	11.9	12.4
Asarum canadense L.	5.9	7.7	6.8
Viola cf. *canadensis* L.	4.9	8.4	6.7
Allium tricoccum Ait.	2.9	2.8	2.9
Prunus virginiana L.	1.1	3.5	2.3
Dicentra cucullaria (L.) Bernh.	1.5	2.8	2.2
Smilacina stellata (L.) Desf.	1.4	2.1	1.8
Erigeron philadelphicus L.	1.1	2.1	1.6
Sanguinaria canadensis L.	1.6	1.4	1.5
Dicentra canadensis (Goldie) Walp.	0.6	2.1	1.4
Claytonia virginica L.	0.9	1.4	1.2
Euonymus obovatus Nutt.	0.9	1.4	1.2
Geum canadense Jacq.	0.4	1.4	0.9
Cardamine douglassii (Torr.) Britt.	0.3	1.4	0.9
Rubus sp.	0.2	0.7	0.5
Ribes americanum Mill.	0.1	0.7	0.4

deltoides Marsh. is a common woody component of the disturbed area nearest the university housing. *Phalaris arundinacea* L. forms dense stands in places on the west and east side of the old river channel. In disturbed places

along the riverbank north of Kalamazoo Street, the second author found *Cannabis sativa* L. and *Lycopersicon esculentum* Mill. after the 1975 flood. However, these species have not persisted. Other species found only in this area north of Kalamazoo Street include: *Diarrhena americana* Beauv., on the state list of threatened species (Beaman et al. 1985), *Amaranthus tuberculatus* (Moq.) Sauer, and *A. retroflexus* L.

CONCLUSIONS

The Red Cedar Natural Area is a highly disturbed floodplain community located along the Red Cedar River. In the broadest sense it is a floodplain forest with *Acer nigrum, A. saccharinum* and *A. saccharum* the most important woody species. Many other typical floodplain species are also found within the wooded portion of the tract. The highly disturbed nature of the area can be seen by the sizeable acreage of old field within the tract and by the abundance of *Toxicodendron radicans* in the wooded portion of the area.

Despite its disturbed nature, however, the Red Cedar Natural Area is still very valuable. It supports *Diarrhena americana,* a state threatened species as well as serving as a valuable buffer zone between the city of Lansing and the Michigan State University campus. Furthermore, it absorbs the flood waters of the Red Cedar River during periods of high water level and thus prevents flood damage to surrounding inhabited areas.

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A STUDY OF RED CEDAR NATURAL AREA, II. CHECKLIST OF VASCULAR PLANTS

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The previous portion of this study described the historical background and vegetation of the Red Cedar Natural Area (Kron & Walters, 1986). Presented here is a checklist of vascular plants collected in the area. All collections have been made within the past 40 years with the bulk of the specimens collected between 1974 and 1977. Unless otherwise indicated all of the collections cited are deposited in the Beal-Darlington Herbarium of Michigan State University.

The horsetails and ferns are listed first, followed by the flowering plants which are listed according to Cronquist's (1981) systematic arrangement. Nomenclature follows that of Gleason & Cronquist (1963) for the horsetails, ferns, and dicotyledons, and that of Voss (1972) for the monocots. The checklist includes 80 families, 192 genera, and 314 species. Introduced and escaped species comprise approximately 20 percent of the flora. The largest family represented is the Asteraceae with 36 species and 15 genera. Poaceae have 25 species in 17 genera and Liliaceae have 17 species in 8 genera. Other families with 10 or more genera include Brassicaceae and Lamiaceae. *Aster* and *Viola* have 8 species each. *Diarrhena americana* is the only species found in the Red Cedar Natural Area presently on the state list of endangered and threatened species (Beaman et al. 1985).

EQUISETOPHYTA (Horsetails)

EQUISETACEAE (Horsetail Family)
Equisetum arvense L. Horsetail. *Crow 2102; Scoviac 354, 402.*

POLYPODIOPHYTA (Ferns)

OPHIOGLOSSACEAE (Adder's tongue Family)
Botrychium virginianum (L.) Sw. Rattlesnake fern. *Kron 235.*
POLYPODIACEAE (Polypody Family)
Matteuccia struthiopteris (L.) Todaro. Ostrich fern. *Anderson 2274; Scoviac 389.*
Onoclea sensibilis L. Sensitive fern. *Kron 224; Scoviac 397.*

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MAGNOLIOPHYTA (Angiosperms)
MAGNOLIATAE (Dicotyledons)
MAGNOLIIDAE

LAURACEAE (Laurel Family)
Lindera benzoin (L.) Blume. Spicebush. *Bilodeau & Gould 82, 101; Crow 1936, 1942, 1951, 2005; Kron 70, 157; Scoviac 195.*
ARISTOLOCHIACEAE (Birthwort Family)
Asarum canadense L. Wild ginger. *Bilodeau & Gould 13; Crow 1940, 1967; Scoviac 126.*
CERATOPHYLLACEAE (Hornwort Family)
Ceratophyllum demersum L. Hornwort. *Crow 2097; Scoviac 359.*
RANUNCULACEAE (Crowfoot Family)
Anemone canadensis L. Anemone. *Bilodeau & Gould 42; Kron 215; Scoviac 151.*
A. quinquefolia L. Wood anemone. *Bilodeau & Gould 61.*
A. virginiana L. Anemone. *Scoviac 211.*
Hydrastis canadensis L. *Parmelee 149.*
Isopyrum biternatum (Raf.) T. & G. False rue-anemone. *Crow 1941, 1978; Kron 129; Scoviac 124, 136; Suttkus 10.*
Ranunculus abortivus L. Small-flowered crowfoot. *Crow 1959; Kron 164; Scoviac 140.*
R. fascicularis Muhl. Buttercup. *Parmelee 243.*
R. septentrionalis Poir. Swamp buttercup. *Crow 1947; Kron 152; Scoviac 130.*
Thalictrum dasycarpum Fisch. & Ave-Lall. Purple meadow rue. *Bilodeau & Gould 4, 5, 8; Crow 2015, 2024; Erickson 10; Kron 177, 178; Scoviac 160.*
BERBERIDACEAE (Barberry Family)
Berberis thunbergii DC. Japanese barberry. *Scoviac 246.* Introduced.
Caulophyllum thalictroides (L.) Michx. Blue cohosh. *Kron 136; Scoviac 198.*
MENISPERMACEAE (Moonseed Family)
Menispermum canadense L. Moonseed. *Crow 2087; Kron 184; Scoviac 356.*
PAPAVERACEAE (Poppy Family)
Sanguinaria canadensis L. Bloodroot. *Crow 1939, 1964; Janson 49; Kron 135.*
FUMARIACEAE (Fumitory Family)
Dicentra canadensis (Goldie) Walp. Squirrel corn. *Kron 128.*
D. cucullaria (L.) Bernh. Dutchman's breeches. *Crow 1934, 1949, 1970; Kron 133; Scoviac 393; Suttkus 11.*

HAMAMELIDAE

PLATANACEAE (Plane tree Family)
Platanus occidentalis L. Sycamore. *Crow 2074; Scoviac 304.*
HAMAMELIDACEAE (Witch-hazel Family)
Hamamelis virginiana L. Witch-hazel. *Bilodeau & Gould 72; Crow 2114; Scoviac 360.*
ULMACEAE (Elm Family)
Celtis occidentalis L. Hackberry. *Anderson 2364; Crow 2069; Kron 46; Scoviac 310.*
Ulmus americana L. American elm. *Crow 2072; Duvendeck 65; Scoviac 307, 325.*
U. rubra Muhl. Slippery elm. *Kron 109.*
CANNABACEAE (Hemp Family)
Cannabis sativa L. Hemp. *Scoviac 287.* Escaped, not persistent.
URTICACEAE (Nettle Family)
Boehmeria cylindrica (L.) Sw. Bog hemp. *Erickson 12; Kron 47; Scoviac 273.*
Laportea canadensis (L.) Wedd. Wood nettle. *Erickson 6; Scoviac 276.*
Pilea pumila (L.) Gray. Clearweed. *Erickson 31; Scoviac 368.*
Urtica dioica L. Nettle. *Erickson 58; Kron 55; Scoviac 277.*
JUGLANDACEAE (Walnut Family)
Carya cordiformis (Wang.) K. Koch. Bitternut hickory. *Crow 2112; Kron 62; Scoviac 345.*
Juglans nigra L. Black walnut. *Crow 2080; Scoviac 315.*

FAGACEAE (Beech Family)

Fagus grandifolia Ehrh. Beech. *Crow 2090, 2110; Kron 66; Scoviac 294.*

Quercus bicolor Willd. Swamp white oak. *Scoviac 392.*

Q. macrocarpa Michx. Bur-oak. *Crow 2081, 2111; Scoviac 343.*

Q. velutina Lam. Black oak. *Scoviac 391.*

BETULACEAE (Birch Family)

Carpinus caroliniana Walt. Ironwood or blue-beech. *Bilodeau & Gould 17; Crow 2093; Kron 162; Scoviac 297.*

Ostrya virginiana (Mill.) K. Koch. Ironwood or hop-hornbeam. *Kron 69; Scoviac 316.*

CARYOPHYLLIDAE

PHYTOLACCACEAE (Pokeweed Family)

Phytolacca americana L. Pokeweed. *Scoviac 331.*

CHENOPODIACEAE (Goosefoot Family)

Chenopodium album L. Lamb's quarters. *Erickson 63; Crow 2068; Gillis 2808; Kron 52; Scoviac 355.*

AMARANTHACEAE (Amaranth Family)

Amaranthus retroflexus L. Pigweed. *Scoviac 350.* Introduced.

A. tuberculatus (Moq.) Sauer. Water hemp. *Erickson 64, 65; Scoviac 352, 353.*

PORTULACACEAE (Purslane Family)

Claytonia virginica L. Spring beauty. *Crow 1929; Kron 132; Scoviac 125.*

CARYOPHYLLACEAE (Pink Family)

Stellaria media (L.) Cyrill. Common chickweed. *Scoviac 241.* Introduced.

POLYGONACEAE (Smartweed Family)

Polygonum convolvulus L. Black bindweed. *Kron 59; Scoviac 282.* Introduced.

P. lapathifolium L. Smartweed. *Erickson 66.*

P. pensylvanicum L. Smartweed. *Erickson 67; Kron 54; Scoviac 328.*

P. persicaria L. Smartweed. *Crow 2100; Erickson 69; Scoviac 286, 383.* Introduced.

P. punctatum Ell. Smartweed. *Scoviac 362.*

P. scandens L. False buckwheat. *Erickson 59; Gillis 2823.* Introduced.

P. virginianum L. Jumpseed. *Bilodeau & Gould 89, 103, 110; Crow 1975; Erickson 7, 61; Gillis 2540; Scoviac 268.*

Rumex obtusifolius L. Bitter dock. *Scoviac 193.* Introduced.

DILLENIIDAE

CLUSIACEAE (St. John's-wort Family)

Hypericum perforatum L. St. John's-wort. *Bilodeau & Gould 51, 60; Scoviac 204.*

H. punctatum Lam. St. John's-wort. *Bilodeau & Gould 93, 111; Scoviac 219.*

TILIACEAE (Linden Family)

Tilia americana L. Linden or basswood. *Crow 2073; Kron 67; Scoviac 305.*

VIOLACEAE (Violet Family)

Viola canadensis L. Canada violet. *Crow 1966, 2022, 2084.*

V. cucullata Ait. Blue marsh violet. *Crow 1945, 1960; Kron 155; Scoviac 123, 132.*

V. papilionacea Pursh. Meadow violet. *Anderson 2266, 2276; Kron 153.*

V. pubescens var. *eriocarpa* (Schw.) Russell. Smooth yellow violet. *Scoviac 395.*

V. pubescens Ait. var. *pubescens.* Yellow violet. *Crow 1954; Helma 2; Scoviac 121, 167.*

V. rotundifolia Michx. Round-leaved yellow violet. *Kron 154.*

V. sororia Willd. Blue violet. *Anderson 2275; Crow 1981; Kron 137, 149, 156.*

V. striata Ait. Cream violet. *Anderson 2277; Crow 1950; Erickson 30, 37, 74; Kron 80, 150; Scoviac 120.*

CUCURBITACEAE (Gourd Family)

Echinocystis lobata (Michx.) T. & G. Prickly cucumber. *Bilodeau & Gould 74, 79; Bordner 23, 59; Crow 1984, 1994, 2078; Erickson 29; Gillis 2650, 2807; Kron 56; Scoviac 235, 272.*

SALICACEAE (Willow Family)

Populus deltoides Marsh. Cottonwood. *Crow 1953, 2008, 2070; Scoviac 303.*

Salix amygdaloides Anderss. Peach-leaf willow. *Crow 1956, 1985.*

S. humilis Marsh. Upland willow. *Crow 1931.*

S. interior Rowlee. Sandbar willow. *Bilodeau & Gould 23; Crow 1957; Scoviac 192, 480, 481.*

S. serissima (Bailey) Fern. Autumn willow. *Parmelee 3337.1.*

BRASSICACEAE (Mustard Family)

Arabis laevigata (Muhl.) Poir. Rock cress. *Crow 1977; Erickson 17, 45; Kron 143, 160, 163, 194; Scoviac 483.*

A. hirsuta (L.) Scop. Rock cress. *Scoviac 406.*

Barbarea vulgaris R. Br. Winter cress or yellow rocket. *Crow 1991; Scoviac 150, 158.*

Berteroa incana (L.) DC. Hoary alyssum. *Kron 182; Scoviac 232.* Introduced.

Brassica campestris L. Field mustard. *Bilodeau & Gould 25, 34.* Introduced.

B. kaber (DC.) L. Wheeler. Charlock. *Bilodeau & Gould 22.*

Cardamine bulbosa (Schreb.) BSP. Bitter cress. *Kron 145.*

C. douglassii (Torr.) Britt. Spring cress. *Crow 1928, 1933, 1972, 1980; Kron 131; Scoviac 129.*

C. pensylvanica Willd. *Scoviac 330.*

Dentaria laciniata Muhl. Toothwort. *Crow 1944, 1971, 2009; Kron 130; Scoviac 128.*

Erysimum cheiranthoides L. Wormseed-mustard. *Erickson 47; Scoviac 182.*

Hesperis matronalis L. Dame's violet. *Bilodeau & Gould 12, 33; Crow 1995, 2016; Erickson 18; Gillis 2516; Kron 233; Scoviac 143.* Introduced.

Lepidium virginicum L. Peppergrass. *Kron 187; Scoviac 351.*

Nasturtium officinale R. Br. Watercress. *Scoviac 330.*

PRIMULACEAE (Primrose Family)

Lysimachia ciliata L. Loosestrife. *Bilodeau & Gould 49, 50, 62; Erickson 27; Gillis 2535, 2812.*

L. nummularia L. Moneywort. *Bilodeau & Gould 24; Kron 79; Scoviac 179.* Introduced.

L. punctata L. Loosestrife. *Scoviac 134.* Introduced.

Samolus floribundus HBK. Water-pimpernel. *Scoviac 201.*

ROSIDAE

GROSSULARIACEAE (Gooseberry Family)

Ribes americanum Mill. Gooseberry. *Bilodeau & Gould 15; Crow 1961, 1970; Kron 142, 166; Scoviac 137, 252.*

ROSACEAE (Rose Family)

Agrimonia gryposepala Wallr. Agrimony. *Bilodeau & Gould 41, 46; Scoviac 180.*

Crataegus sp. Hawthorn. *Crow 2007; Scoviac 326.*

Fragaria virginiana Duchesne. Strawberry. *Kron 139, 144.*

Geum canadense Jacq. Avens. *Bilodeau & Gould 1, 36; Erickson 3, 8; Gillis 2521; Scoviac 177.*

G. laciniatum Murr. Avens. *Scoviac 171, 254.*

Physocarpus opulifolius (L.) Maxim. Ninebark. *Scoviac 484.*

Potentilla inclinata Vill. Cinquefoil. *Kron 211; Scoviac 363.* Introduced.

P. norvegica L. Cinquefoil. *Bilodeau & Gould 52; Scoviac 227.*

P. recta L. Cinquefoil. *Kron 212; Scoviac 154, 175, 380.* Introduced.

Prunus insititia L. Damson plum. *Scoviac 394.* Introduced.

P. malaheb L. Malaheb cherry. *Scoviac 467.* Escaped.

P. nigra Ait. Canada plum. *Kron 58.*

P. virginiana L. Choke cherry. *Bilodeau & Gould 66, 69, 84; Crow 2002; Kron 57, 58A, 105, 106, 107, 141; Scoviac 142, 215, 298.*

Rosa multiflora Thunb. Rose. *Kron 218; Scoviac 172.* Introduced.

Rubus allegheniensis Porter. Common blackberry. *Bilodeau & Gould 45; Kron 217.*

R. occidentalis L. Black raspberry. *Bilodeau & Gould 63; Erickson 101; Scoviac 183, 222.*
R. flagellaris L. Red raspberry. *Scoviac 153.*
R. pensylvanicus Poir. Blackberry. *Scoviac 223, 270.*
Spiraea alba DuRoi. Meadow sweet. *Bilodeau & Gould 40; Scoviac 228.*

FABACEAE (Pea Family)
Medicago lupulina L. Black medick. *Scoviac 214.* Introduced.
M. sativa L. Alfalfa. *Scoviac 238.* Introduced.
Melilotus alba Desr. White sweet clover. *Scoviac 203.* Introduced.
M. officinalis (L.) Desr. Yellow sweet clover. *Scoviac 135.* Introduced.
Robinia pseudoacacia L. Black locust. *Scoviac 295.*
Trifolium hybridum L. Alsike clover. *Scoviac 206.* Introduced.
T. repens L. White clover. *Scoviac 205.*

ONAGRACEAE (Evening primrose Family)
Circaea quadrisulcata (Maxim.) Franch & Sav. Enchanter's nightshade. *Bilodeau & Gould 20, 67; Erickson 23, 34; Gillis 2522; Scoviac 178.*
Ludwigia palustris (L.) Ell. *Crow 2103; Scoviac 366.*
Oenothera biennis L. Evening primrose. *Bilodeau & Gould 94; Erickson 21, 35; Scoviac 243, 257.*

CORNACEAE (Dogwood Family)
Cornus alternifolia L.f. Alternate-leaved dogwood. *Crow 194, 261, 2006, 2091; Kron 140.*
C. amomum Mill. Dogwood. *Crow 2109; Scoviac 361, 385.*
C. florida L. Flowering dogwood. *Crow 2001.*
C. purpusi Koehne. Dogwood. *Kron 174.*
C. racemosa Lam. Dogwood. *Scoviac 199, 384.*
C. stolonifera Michx. Red osier. *Crow 2092; Kron 165, 210; Scoviac 145, 369.*

CELASTRACEAE (Staff tree Family)
Euonymus atropurpureus Jacq. Burning bush or wahoo. *Bilodeau & Gould 38; Gillis 2822.*
E. europaeus L. Burning bush or wahoo. *Scoviac 396.* Introduced.
E. obovatus Nutt. Running strawberry-bush. *Kron 159; Scoviac 311.*

EUPHORBIACEAE (Spurge Family)
Acalypha virginica L. Three-seeded mercury. *Scoviac 390.*

RHAMNACEAE (Buckthorn Family)
Rhamnus catharticus L. Common buckthorn. *Bilodeau & Gould 75, 83; Crow 1987, 2079; Kron 71; Scoviac 312.* Introduced.
R. frangula L. Buckthorn. *Kron 110, 190.* Introduced.

VITACEAE (Grape Family)
Vitis aestivalis Michx. Summer grape. *Kron 209.*
V. riparia Michx. Frost grape. *Bilodeau & Gould 30; Erickson 102; Crow 1988, 2085; Scoviac 189.*

STAPHYLEACEAE (Bladdernut Family)
Staphylea trifolia L. Bladdernut. *Anderson 2305; Crow 1968, 1982; Kron 68, 140, 191; Scoviac 138, 341.*

ACERACEAE (Maple Family)
Acer negundo L. Box-elder. *Bilodeau & Gould 85; Crow 1937, 1938, 1958, 1986, 2076; Janson 77; Kron 84; Scoviac 299, 364.*
A. nigrum Michx.f. Black maple. *Anderson 2365; Crow 2010; Kron 85, 108; Scoviac 296.*
A. rubrum L. Red maple. *Crow 1952, 2077.*
A. saccharinum L. Silver maple. *Janson 76; Scoviac 291.*
A. saccharum Marsh. Sugar maple. *Crow 1955, 2013; Janson 78; Kron 83; Scoviac 308, 365.*

ANACARDIACEAE (Cashew Family)
Rhus glabra L. Smooth sumac. *Scoviac 314.*
R. typhina L. Staghorn sumac. *Erickson 75.*

Toxicodendron radicans subsp. *negundo* (Greene) Gillis. Poison-ivy. *Bilodeau & Gould 116; Gillis 2409, 2462, 2464, 2517; Scoviac 249.*

RUTACEAE (Rue Family)

Ptelea trifoliata L. Wafer-ash or hop-tree. *Anderson 2363; Bilodeau & Gould 26, 71, 81; Crow 2014; Scoviac 255.*

Zanthoxylum americanum Mill. Prickly ash. *Crow 1962, 1993, 2071; Kron 158; Scoviac 398.*

OXALIDACEAE (Wood-sorrel Family)

Oxalis dillenii Jacq. Wood-sorrel. *Erickson 14, 25; Scoviac 148.*

GERANIACEAE (Geranium Family)

Geranium maculatum L. Wild geranium. *Crow 1973; Kron 151, 167; Scoviac 122.*

LIMNANTHACEAE (False-mermaid Family)

Floerkea proserpinacoides Willd. False-mermaid. *Anderson 2306.*

BALSAMINACEAE (Touch-me-not Family)

Impatiens biflora Walt. Spotted touch-me-not. *Scoviac 275.*

I. pallida Nutt. Touch-me-not. *Erickson 16, 19; Gillis 2815; Scoviac 332.*

APIACEAE (Parsley Family)

Cryptotaenia canadensis (L.) DC. Honewort. *Erickson 24, 36.*

Daucus carota L. Wild carrot or Queen Anne's lace. *Bilodeau & Gould 59; Erickson 50; Scoviac 239.* Introduced.

Osmorhiza claytoni (Michx.) Clarke. Sweet cicely. *Scoviac 147.*

O. longistylis (Torr.) DC. Sweet cicely. *Bilodeau & Gould 32.*

Sanicula gregaria Bickn. Black snakeroot. *Erickson 5, 9; Gillis 2617; Scoviac 197.*

Torilis japonica (Houtt.) DC. Hedge parsley. *Bilodeau & Gould 70, 95; Scoviac 258.* Introduced.

ASTERIDAE

APOCYNACEAE (Dogbane Family)

Apocynum cannabinum L. Indian hemp. *Bilodeau & Gould 43, 92; Kron 183, 186; Scoviac 229.*

A. sibiricum Jacq. Indian hemp. *Kron 269.*

ASCLEPIADACEAE (Milkweed Family)

Asclepias incarnata L. Swamp milkweed. *Bilodeau & Gould 48, 86; Kron 60; Scoviac 234.*

A. syriaca L. Common milkweed. *Scoviac 226.*

Cynanchum nigrum (L.) Pers. Black swallow-wort. *Bilodeau & Gould 16; Scoviac 323.* Introduced.

SOLANACEAE (Nightshade Family)

Lycopersicon esculentum Mill. Tomato. *Erickson 51; Scoviac 286.* Escaped.

Physalis heterophylla Nees. Ground cherry. *Bilodeau & Gould 39; Kron 74; Scoviac 231.*

Solanum carolinense L. Horse nettle. *Kron 234; Scoviac 221.*

S. dulcamara L. Bittersweet nightshade. *Bilodeau & Gould 14; Erickson 13; Scoviac 159, 184.* Introduced.

S. nigrum L. Black nightshade. *Erickson 49; Scoviac 290.*

CONVOLVULACEAE (Morning-glory Family)

Convolvulus sepium L. Hedge bindweed. *Bilodeau & Gould 10, 44; Scoviac 176.*

CUSCUTACEAE (Dodder Family)

Cuscuta gronovii Willd. Dodder. *Erickson 54, 72; Gillis 2811.*

POLEMONIACEAE (Phlox Family)

Phlox divaricata L. var. *divaricata*. Phlox. *Crow 1965, 1989; Kron 161, 230; Scoviac 139.*

P. divaricata var. *laphamii* Wood. Phlox. *Anderson 2273.*

P. paniculata L. Phlox. *Erickson 40.* Escaped.

HYDROPHYLLACEAE (Waterleaf Family)

Hydrophyllum appendiculatum Michx. Waterleaf. *Bilodeau & Gould 11; Kron 185, 221.*

H. canadense L. Waterleaf. *Bilodeau & Gould 21, 108; Kron 207, 222; Scoviac 166.*
H. virginianum L. Waterleaf. *Kron 208, 223; Scoviac 292.*

BORAGINACEAE (Borage Family)
Hackelia virginiana (L.) Johnst. Stickseed. *Erickson 33, 41; Scoviac 242.*

VERBENACEAE (Vervain Family)
Verbena hastata L. Vervain. *Scoviac 405.*
V. urticifolia L. White vervain. *Erickson 56; Gillis 2541, 2813; Scoviac 253.*

LAMIACEAE (Mint Family)
Agastache neptoides (L.) Kuntze. Giant hyssop. *Bilodeau & Gould 106; Scoviac 284.*
Belphilia hirsuta (Pursh) Benth. *Scoviac 218.*
Glecoma hederacea L. Ground ivy. *Anderson 2272.* Introduced.
Leonurus cardiaca L. Motherwort. *Bilodeau & Gould 28; Scoviac 190.* Introduced.
Lycopus americanus Muhl. Water horehound. *Parmelee 3259.*
Mentha arvensis L. Mint. *Scoviac 251.*
Monarda fistulosa L. Wild bergamot. *Bilodeau & Gould 47, 96; Erickson 20; Scoviac 225.*
Prunella vulgaris L. Heal-all. *Bilodeau & Gould 64, 78; Erickson 39; Scoviac 209.*
Scutellaria lateriflora L. Mad-dog skullcap. *Erickson 87; Scoviac 266.*
Stachys tenuifolia Willd. Hedge nettle. *Bilodeau & Gould 102; Erickson 15; Scoviac 250, 262.*
Teucrium canadense L. Wood sage. *Bilodeau & Gould 65, 68; Erickson 32, 38; Kron 267, 275; Scoviac 217.*

PLANTAGINACEAE (Plantain Family)
Plantago aristata Michx. Buckhorn. *Kron 193.*
P. lanceolata L. Buckhorn. *Bilodeau & Gould 57, 105; Kron 192; Scoviac 213.* Introduced.
P. rugelii Decne. Plantain. *Gillis 2539; Scoviac 388.*

OLEACEAE (Olive Family)
Fraxinus americana L. White ash. *Crow 2075, 2089; Scoviac 293.*
F. pensylvanica Marsh. Red ash. *Anderson 2367; Scoviac 306.*
F. quadrangulata Michx. Blue ash. *Anderson 2366; Parmelee 3380.*
Ligustrum vulgare L. Privet. *Kron 175; Scoviac 342.* Introduced.

SCROPHULARIACEAE (Figwort Family)
Chelone glabra L. Turtlehead. *Crow 2098; Scoviac 327.*
Linaria vulgaris Hill. Toadflax. *Bilodeau & Gould 56; Kron 75; Scoviac 265.* Introduced.
Mimulus ringens L. Monkey flower. *Bilodeau & Gould 76, 90; Erickson 28; Gillis 2512, 2544; Scoviac 279.*
Penstemon hirsutus (L.) Willd. Beard-tongue. *Parmelee 539.*
Scrophularia marilandica L. Figwort. *Erickson 44; Gillis 2809; Kron 72; Scoviac 256.*
Verbascum blattaria L. Moth-mullein. *Bilodeau & Gould 80; Erickson 77; Scoviac 173.* Introduced.
V. thapsus L. Mullein. *Scoviac 344.*
Veronicastrum virginicum (L.) Farw. Culver's root. *Bilodeau & Gould 91, 107; Erickson 76; Gillis 2619; Kron 272; Scoviac 247, 300.*

BIGNONIACEAE (Trumpet Creeper Family)
Catalpa speciosa Warder. Catalpa. *Scoviac 278.*

CAMPANULACEAE (Bluebell Family)
Campanula americana L. Tall bellflower. *Erickson 48; Gillis 2538; Scoviac 248.*
Lobelia cardinalis L. Cardinal flower. *Erickson 73; Scoviac 289.*
L. siphilitica L. Lobelia. *Scoviac 302.*

RUBIACEAE (Madder Family)
Cephalanthus occidentalis L. Buttonbush. *Crow 2107; Scoviac 288.*
Galium obtusum Bigel. Bedstraw. *Scoviac 168.*
G. triflorum Michx. Sweet-scented bedstraw. *Erickson 43.*

CAPRIFOLIACEAE (Honeysuckle Family)
Lonicera morrowi Gray. Honeysuckle. *Scoviac 185.* Escaped.
L. tatarica L. Honeysuckle. *Bilodeau & Gould 31; Kron 146.* Introduced.

Sambucus canadensis L. Common elder. *Bilodeau & Gould 35; Erickson 26; Scoviac 181.*
Viburnum opulus L. High-bush cranberry. *Scoviac 333.*
V. lentago L. Sheepberry. *Kron 111, 189.*

DIPSACACEAE (Teasel Family)
Dipsacus sylvestris Huds. Teasel. *Helma 4; Kron 77; Scoviac 259.* Introduced.

ASTERACEAE (Aster Family)
Achillea millefolium L. Common yarrow. *Kron 213; Scoviac 200.*
Ambrosia artemisiifolia L. Common ragweed. *Erickson 72; Kron 49; Scoviac 334.*
A. trifida L. Great ragweed. *Erickson 68; Gillis 2816; Scoviac 271.*
Antennaria plantaginifolia (L.) Richards. Pussytoes. *Scoviac 470.*
Aster ciliolatus Lindl. Aster. *Kron 44.*
A. cordifolius L. Aster. *Gillis 2819.*
A. ericoides L. Aster. *Erickson 82, 83.*
A. ontarionis Weig. Aster. *Kron 48.*
A. pilosus Willd. Aster. *Scoviac 322, 387.*
A. puniceus L. Aster. *Scoviac 386.*
A. novae-angliae L. Aster. *Kron 50; Scoviac 340.*
A. sagittifolius Willd. Aster. *Beaman 2625; Erickson 80; Scoviac 347.*
Bidens cernua L. Stick-tight. *Crow 2094; Scoviac 329, 346.*
B. frondosa L. Beggar-ticks. *Erickson 85.*
B. vulgata Greene. Beggar-ticks. *Erickson 79; Kron 78.*
Chrysanthemum leucanthemum L. Daisy. *Kron 173, 220; Scoviac 174.* Introduced.
Cichorium intybus L. Chicory. *Gillis 2513; Scoviac 339.*
Cirsium horridulum Michx. Thistle. *Kron 270.*
C. vulgare (Savi) Tenore. Bullthistle. *Erickson 78; Scoviac 264.* Introduced.
Erigeron annuus (L.) Pers. Fleabane. *Bilodeau & Gould 9, 53, 54; Erickson 81, 84; Gillis 2545; Scoviac 186, 317.*
E. philadelphicus L. Fleabane. *Kron 172, 219; Scoviac 169.*
E. strigosus Muhl. var. *strigosus*. Fleabane. *Gillis 2634.*
Eupatorium purpureum L. Joe pye-weed. *Bilodeau & Gould 88; Erickson 11; Gillis 2620; Scoviac 260, 321.*
E. rugosum Houtt. White snakeroot. *Crow 2067; Erickson 60; Gillis 2820; Kron 45; Scoviac 283.*
Helianthus decapetalus L. Sunflower. *Bilodeau & Gould 97, 99, 100.*
H. giganteus L. Sunflower. *Kron 268A; Scoviac 281, 313.*
Hieracium aurantiacum L. King devil. *Kron 171.* Introduced.
Rudbeckia hirta L. Black-eyed Susan. *Scoviac 236.*
R. laciniata L. Coneflower. *Bilodeau & Gould 113; Erickson 53, 57; Gillis 2814; Scoviac 267.*
Solidago canadensis L. Goldenrod. *Erickson 71; Gillis 2821; Scoviac 318.*
S. flexicaulis L. Goldenrod. *Scoviac 338.*
S. gigantea Ait. Goldenrod. *Erickson 86; Scoviac 319.*
S. graminifolia (L.) Salisb. Goldenrod. *Bilodeau & Gould 104.*
S. nemoralis Ait. Goldenrod. *Kron 268; Scoviac 280.*
Sonchus oleraceus L. Sow-thistle. *Bilodeau & Gould 55, 73, 87.* Introduced.
S. uliginosus Bieb. Sow-thistle. *Bilodeau & Gould 98; Scoviac 212.* Introduced.
Taraxacum officinale Weber. Dandelion. *Crow 1998; Scoviac 131.* Introduced.

LILIATAE (Monocotyledons)
ALISMATIDAE

ALISMATACEAE (Water-plantain Family)
Alisma plantago-aquatica L. Water-plantain. *Gillis 2511; Scoviac 224, 400.*
Sagittaria cuneata Sheldon. Arrowhead. *Scoviac 274.*

HYDROCHARITACEAE (Frog's bit Family)
Elodea canadensis Michx. Waterweed. *Crow 2106; Scoviac 357.*

POTAMOGETONACEAE (Pondweed Family)
Potamogeton crispus L. Pondweed. *Scoviac 399.* Introduced.

P. gramineus L. Pondweed. *Crow 2096.*
P. pusillus L. Pondweed. *Scoviac 403.*

ARECIDAE

ARACEAE (Arum Family)
Arisaema dracontium (L.) Schott. Green dragon. *Scoviac 161.*
LEMNACEAE (Duckweed Family)
Lemna minor L. Duckweed. *Kron 81.*

COMMELINIDAE

JUNCACEAE (Rush Family)
Juncus effusus L. Rush. *Scoviac 210.*
CYPERACEAE (Sedge Family)
Carex amphibola Steudel. *Kron 196, 199.*
C. bebbii (Bailey) Fern. *Kron 197, 200; Scoviac 404.*
C. cephaloidea (Dewey) Dewey. *Scoviac 155.*
C. foenea Willd. *Kron 202.*
C. grayi Carey. *Crow 2095; Gillis 2519; Parmelee 196; Kron 176, 201; Scoviac 191.*
C. projecta Mack. *Kron 227.*
Cyperus strigosus L. *Scoviac 367.*
Eleocharis olivacea Torr. *Kron 180.*
Scirpus cyperinus (L.) Kunth. *Scoviac 220.*
POACEAE (Grass Family)
Agrostis gigantea Roth. *Kron 64.*
A. stolonifera L. *Erickson 105; Scoviac 208.* Introduced.
Bromus ciliatus L. *Kron 61, 63.*
B. inermis Leyss. Bromegrass. *Erickson 103; Kron 51; Scoviac 237.* Introduced.
B. latiglumis (Shear.) Hitchc. Bromegrass. *Erickson 88, 98.*
B. pubescens Willd. *Kron 65.*
Cinna arundinacea L. Wood reed. *Erickson 89; Kron 64.*
Diarrhena americana Beauv. *Crow 2115* (MICH); *Erickson 100.*
Digitaria sanguinalis (L.) Scop. *Erickson 109.* Introduced.
Echinochloa crusgalli (L.) Beauv. Barnyard grass. *Kron 73.* Introduced.
E. muricata (Beauv.) Fern. Barnyard grass. *Erickson 92, 93; Scoviac 349, 381.*
Elymus villosus Willd. Wild rye. *Erickson 99; Scoviac 188.*
E. virginicus L. Wild rye. *Erickson 94; Kron 43.*
Eragrostis pectinacea (Michx.) Nees. Love grass. *Erickson 106.*
E. spectabilis (Pursh) Steud. Love grass. *Erickson 90.*
Leersia virginica Willd. White grass. *Kron 76, 274; Erickson 108.*
Lolium multiflorum Lam. English rye grass. *Erickson 104.* Introduced.
Muhlenbergia frondosa (Poir.) Fern. Muhly. *Erickson 110.*
Panicum capillare L. Witch grass. *Erickson 97; Kron 53, 271.*
P. dichotomiflorum Michx. Witch grass. *Erickson 107.*
Phalaris arundinacea L. Reed grass. *Kron 195; Scoviac 156, 263.*
Phleum pratense L. Timothy. *Kron 273; Scoviac 207.* Introduced.
Poa nemoralis L. Bluegrass. *Kron 198, 274A.* Introduced.
Setaria glauca (L.) Beauv. Foxtail grass. *Erickson 95.* Introduced.
S. viridus (L.) Beauv. Foxtail grass. *Erickson 96.* Introduced.
Sphenopholis intermedia (Rydb.) Rydb. *Kron 203.*

LILIIDAE

LILIACEAE (Lily Family)
Allium canadense L. Wild garlic. *Scoviac 157, 164, 269, 290.*

A. oleraceum L. Onion. *Erickson 22.*
A. sativum L. Garlic. *Kron 181, 214, 229.* Introduced.
A. tricoccum Ait. Wild leek. *Bilodeau & Gould 19; Crow 2019, 2082; Erickson 4; Scoviac 245.*
Asparagus officinalis L. Asparagus. *Kron 216; Scoviac 244.* Introduced.
Erythronium albidum Nutt. *Kron 138.*
E. americanum Ker. Adder's tongue. *Crow 1943; Kron 134; Scoviac 127.*
Polygonatum biflorum (Walt.) Ell. Solomon's seal. *Crow 1997, 2017; Erickson 55; Scoviac 163.*
Smilacina racemosa (L.) Desf. False Solomon's seal. *Crow 1969; Kron 228; Scoviac 196.*
S. stellata (L.) Desf. False Solomon's seal. *Crow 1983; Kron 147, 148; Scoviac 144.*
Smilax ecirrata (Kunth) S. Watson. *Kron 169, 225.*
S. herbacea L. Greenbrier. *Scoviac 146.*
S. hispida Torr. Greenbrier. *Scoviac 162.*
S. illinoensis Mangaly. *Kron 170, 226.*
Trillium flexipes Raf. Trillium. *Anderson 2267; Crow 1948, 1974, 2004; Scoviac 133, 165.*
T. grandiflorum (Michx.) Salisb. Trillium. *Crow 1963; Scoviac 141.*
Uvularia grandiflora Sm. Bellwort. *Kron 168.*

IRIDACEAE (Iris Family)
Iris virginica L. Iris. *Scoviac 152.*
Sisyrinchium angustifolium Mill. Blue-eyed grass. *Kron 206; Scoviac 170.*

DIOSCOREACEAE (Yam Family)
Dioscorea villosa L. Wild yam. *Bilodeau & Gould 58; Scoviac 202, 233.*

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Kron, K. A., & B. S. Walters. 1986. A study of Red Cedar Natural Area. I. Historical background and description of the vegetation. Michigan Bot. 25: 27–34.

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Errata

1. Brian (not Bryan) Hazlett's name was misspelled in the list of reviewers, as was Gary L. Hannan's (not Hannon's). We apologize for the errors.
2. The issue number given in the second sentence of the erratum in the October issue (Vol. 24, no. 4) should be 2 not 3. The sentence should read: "The correct publication date for Vol 24, no. 2 is May 11, 1985."

2,45

ALPINE HEDYSARUM (HEDYSARUM ALPINUM) DISCOVERED IN MICHIGAN

Kim Alan Chapman
Michigan Natural Features Inventory
Mason Building, Box 30028
Lansing, MI 48909

While conducting an ecological survey of the banks of the lower Escanaba River in Delta County, Upper Michigan, I encountered a small population of *Hedysarum alpinum* L., a legume that looks like an *Astragalus* by its pinnately-compound leaves and for which, in fact, I mistook it.[1] But its purple flowers (Fig. 1, manuals also say pink or magenta) and flat, segmented fruits distinguish *Hedysarum* from *Astragalus,* our two species of which have cream or yellow flowers and swollen fruits. *Hedysarum alpinum* is the only member of the genus in the eastern United States, growing in the mountains of northern Vermont and Maine (Fernald 1950). *H. alpinum* is circumpolar and is found in North America from New Brunswick and Newfoundland west to Alaska and British Columbia and south in the mountains to northern Montana, with outliers in Wyoming and South Dakota (Scoggan 1978). Populations of *H. alpinum* nearest the Delta County population are about 300 km north northwest at the tip of the Sibley Peninsula in Ontario (Given & Soper 1981).

The habitat of *Hedysarum alpinum* is reported to be ''river banks, hills, and ledges in moist soil'' (Gleason 1952), ''calcareous rocks and gravels'' (Fernald 1950), and ''calcareous sands, gravels, rocky slopes, and tundra'' (Scoggan 1978). At the north shore of Lake Superior its principal habitat is cliffs; it also grows in thin-soil herb and shrub communities between beach and forest (Given & Soper 1981). In Michigan it was found in alvar (Catling et al. 1975), a natural community type characterized by a distinctive flora growing on bedrock or, the more prevalent condition, in a thin layer of neutral to moderately alkaline sandy loam or loamy sand (pH 7.2–8.1) overlying horizontal plates of limestone or dolomite. About half of the common alvar species have generally northern distributions, about a fifth range to the southeast, and some plant species more typically grow in prairies.

A dozen scattered plants of *H. alpinum* grew in the upper and driest alvar zone dominated by *Andropogon scoparius* and *Poa compressa.* The river bank here was partly shaded by paper birch, white spruce, cedar, and hemlock. Also found in this zone were *Antennaria* sp., *Astragalus neglectus, Galium boreale, Castilleja coccinea, Festuca rubra,* and over one hundred stems of the threatened dwarf lake iris (*Iris lacustris*). In the middle alvar zone below this one grew the threatened mat muhly (*Muhlenbergia richard-*

[1]Specimen deposited at the Beal-Darlington Herbarium, Michigan State University, East Lansing, Michigan.

Fig. 1. Inflorescence of *Hedysarum alpinum.*

sonis). *Calamagrostis canadensis* and *Spartina pectinata* dominated the lowest moistest alvar zone next to exposed limestone at the river edge.

ACKNOWLEDGMENTS

This study was partly funded by a Living Resources Grant from the Nongame Wildlife Unit, Wildlife Div., Mich. Dept. of Natural Resources. I thank E. G. Voss and A. A. Reznicek for determining the identity of *Hedysarum alpinum*. Dr. Voss also kindly reviewed the manuscript.

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(Page 1)

The October issue (Vol. 24, no. 4) was mailed November 30, 1985.

CONTENTS

On the cover: Hedysarum alpinum, *a new record for Michigan, photographed on the shore of the Escanaba River, Delta Co., Michigan by Sue Crispin, June 25, 1985.*

Vol. 25, No. 2

THE MICHIGAN BOTANIST

March, 1986

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ED VOSS AND THE MICHIGAN FLORA

Ruth B. (Alford) MacFarlane

Mass City, MI 49948

When in November of 1985 Dr. Edward Voss placed his book, *Michigan Flora,* Part II, into the eager hands of students of Michigan plants, he presented them with the distillation of 175 years of botanical work in Michigan and with his own intense effort of the past thirteen years.

Michigan Flora, Part II, contains the names and identification aids for nearly one thousand species of plants in more than eighty families known to occur in Michigan, including most of the woody plants, the rose and legume families, and on through the dogwoods.

The first volume of *Michigan Flora* contained 723 species, comprising the conifers, the monocots, and most of the aquatic flowering plants. Upon its appearance in June of 1972, Part I was immediately honored by the Michigan Legislature in Senate Resolution No. 286, which declared an ''accolade of tribute'' to Dr. Voss and the institutions, organizations, and individuals responsible for ''this meaningful documentation of Michigan's natural heritage, a link uniting our citizens with the beauties of their state.''

A less formal celebration occurred that year at the University of Michigan Biological Station at Douglas Lake, where the Michigan Botanical Club was holding its annual Memorial Day weekend campout. Doreen Judd and Thelma Thomson organized an impromptu lakeside ceremony, complete with cake, at which Genevieve Gillette, grand lady of conservation in Michigan, presented Dr. Voss with a copy of the book's jacket, the book itself not yet being off the Cranbrook Institute of Science press. The celebration marked the culmination of fifteen years' work.

Michigan Flora was begun in 1956 under a five-year grant from the Faculty Research Fund of the Horace H. Rackham School of Graduate Studies of the University of Michigan, which supported the work full-time through the 1960–61 year. Subsequently, the project was included in the regular research program of the University Herbarium. Clerical and other assistance in completing that first part was made possible by another grant (1969–70) from the Faculty Research Fund. Support for publication of both volumes and for preparation of Part II was generously provided by the Clarence R. and Florence N. Hanes Fund. The Michigan Botanical Club paid for the color frontispiece in Part I.

In the preparation of Part II, Voss studied first those specimens in the University of Michigan Herbarium at Ann Arbor, one of the world's major herbaria. Then, by having specimens sent to him on loan or by making personal visits, he combed through the plants found in other herbaria, some in Michigan and some in other parts of the United States—nearly 100,000 plants—verifying the identification of each.

He or his assistants copied the labels of those thousands of plants onto record slips which are now on file at the U. of M. Herbarium, available for consultation. All specimens for which complete data were recorded were rubber-stamped, "Noted, 19____, Michigan Flora Project." For *Michigan Flora,* he condensed the data to provide for each species a description of its habitat and distribution.

While the specimens were being examined and recorded, Voss wrote the text, drafting keys family by family, consolidating all the information into a logical and usable whole. He had constantly to search his own work and that of others for errors, and to interpret the sometimes sketchy information. He chose to use the Englerian sequence of families, not because it is still thought to be a natural evolutionary sequence, but because it is familiar and practicable.

Part II contains 971 distribution maps, 351 line drawings and 51 photos in full color. On the maps, a dot in a county (or island) means that one or more specimens have been examined from that mapping unit. Nearly half the species are illustrated, and the distribution of each in Michigan is mapped—over 24,000 documented county records.

"Each record," Voss says, "is based on an actual specimen, checked and noted for the *Flora*—in short, a *verified* report."

Although he is deeply sensible of his debt to other botanists, past and present, and while he solicited and accepted advice, in the end, he said, "the only clearcut way to draw the line was whether I had seen it myself. The records that went in are those I had seen."

At the inception of the *Michigan Flora* project, Voss was just completing a civilian Selective Service assignment as a research assistant in the Metabolism Research Laboratory, University Hospital. He had previously held assistantships and fellowships at the U. of M. He had earned a B.A. in biology from Denison University, Ohio, in 1950, an M.A. in biology from the U. of M. in 1951, and a Ph.D. from the U. of M. in botany in 1954. He became a research associate at the Herbarium from 1956–61, then Curator of Vascular Plants there from 1961 to the present. He has been successively assistant professor of botany (1960–63), associate professor (1963–69), and full professor (1969), a position he still holds.

He did not set out to become a botanist, he says. At first his stronger interest was in entomology. "I've been collecting insects as long as I can remember—back in grade school, raising caterpillars, etc." Today he maintains a library on insects and an insect collection, and he has served on the governing board of the Michigan Entomological Society. "For relaxation I switch from plants to insects and keep right on going."

Born in Delaware, Ohio, to David O. and Katherine Groesbeck Voss, he was graduated from Woodward High School, Toledo. He has one sister, Eleanor Hendricks, who lives in Dayton. Boyhood summers were spent at his grandparents' cottage at Mackinaw City. "Grandfather was a hay-fever sufferer and bought the cottage in 1930. I got most of my outdoor experience in Michigan. I was at the historical center of Michigan. There were five miles

of water in our front yard that the explorers had gone through.'' Voss still owns the cottage, in the shadow of the Mackinac Bridge.

Four years of high-school English and three of Latin, and one year of Greek at Denison, contributed to his ability to write with grace and precision in a style lightened by touches of wit, qualities not always present in scientific writing. On a field trip he may toss off the derivation of a plant name to help explain its meaning. Says one student, ''He knows how to spell everything *correctly*.''

A bibliography of Voss's professional writings fills two and a half typewritten pages, single spaced (without including abstracts, brief reports, notes, over 100 book reviews and notices, and many letters-to-the-editor.) A list of his honors and awards and the positions he has held occupies a similar space.

His mastery of the language and his penchant for hard work brought him into various editorial positions, such as with the Lepidopterists' Society *News,* and as editor of *The Michigan Botanist* from 1962 to 1976. Internationally, he became Vice Rapporteur and then Rapporteur, Bureau of Nomenclature, for the XI, XII, and XIII International Botanical Congresses at Seattle (1969), Leningrad (1975), and Sydney (1981).

His colleague, Dr. Warren H. Wagner, world-renowned authority on ferns, wrote to me:

> Dr. Edward G. Voss is one of Michigan's most distinguished botanists. He is among the world's authorities on the nomenclature of plants, a field in which he has been a leader for a number of years. Internationally famous for his work on plant names, Dr. Voss is the editor-in-chief of the last *Code of Botanical Nomenclature* which was recently published, and which is used by all botanists. Dr. Voss is also the leading authority on the plants of the Upper Great Lakes region, a subject which he has pursued for nearly forty years. Not only is he an extraordinarily fine teacher, both in his course in Boreal Flora at the University of Michigan Biological Station, but in his course in Aquatic Flowering Plants on the main campus in Ann Arbor, as well as his seminars. Careful, precise, and well organized, Dr. Voss is famous for his eloquent lectures and wealth of knowledge. The two volumes of his master floristic work, *Michigan Flora,* exemplify his exhaustive precision and perfectionism, and we expect that the third volume, which should appear in the next several years, will maintain the same rigorous standards. He has explored all parts of Michigan, as well as many other areas of the Upper Great Lakes, and he has inspired many other botanists, both professional and non-professional, to carry out field work in this region.
>
> As a person, Ed Voss is a delight. Friendly, sympathetic, and encouraging to those around him, he displays a consistently high character and respect for others. A master of critical wit and light-hearted puns, he is a superb conversationalist and raconteur.

> With his never-ending interest in historical affairs, he is a leader in knowledge of past events in the history of Michigan's universities and botanists. To all who know him, Ed Voss is a once in a lifetime experience—an unforgettable individual, a real person.

Reflections of Voss's complex personality come from many voices. Says one student, "He's the reason I'm here at Michigan. Despite all his knowledge he's easy to work with. He will give you another chance if you do something wrong." Says another, "If you want to understand him, you should try to read everything he has written. I think that 'The State of Things' in the *Michigan Academician* [Vol. V, No. 1, Summer, 1972] and the preface to *Michigan Flora* summarize his philosophy."

Voss may express himself seriously in formal writing, but in his daily contact with students he indulges in lighthearted humor. He has been known to offer a "gold-plated hotdog" to the first student to find a rare plant. He is full of outrageous puns. On the day I followed his class around, taking photos, he began with, "You may have thought this class was *ruthless* before. Today we have with us . . . "

On that field trip to the partially flooded marshes of Cheboygan State Park, sloshing ahead of the students with a fine disregard for personal comfort, he wore a wildly flowered shirt in olive and black (Fig. 1), a sort of

Fig. 1. Ed Voss shows a plant to Sandy Beadle, center, and Deborah Neher during a field trip with his Boreal Flora class to Cheboygan State Park.

tropical camouflage. (A gift from his students, it was embellished with an embroidered rendition of Pitcher's thistle.)

One current student said, ''What he brings to his course is enthusiasm, excitement. You go out rain or shine. We'll be going through a jack-pine plain when up ahead someone lets out a shout and everyone comes running. There he'll be pointing out some obscure plant that ordinarily you'd step on.''

Speaking again of the publication of *Michigan Flora,* Ed Voss brought to its researching and writing the seriousness of his ''State of Things'' and the enthusiasm of his teaching. The task, now two-thirds complete, has reached only a temporary halt. Part III, which will cover plant families from the heaths through the composites, lies somewhere down the years, countless research hours away.

MAJOR ERRATA IN MICHIGAN FLORA PART II

Besides a few of the inevitable but largely self-evident typographical errors which escaped proofreading, some more important or misleading oversights have been noted in *Michigan Flora* Part II (Cranbrook Inst. Sci. Bull. 59. 1985). These can be blamed on gremlins who lost data when the final manuscript was being typed, confused the Gray Index, mixed counties on a map, or otherwise obscured the obvious:

p. xi, line 11 from bottom: insert Robert W. Smith, Lenawee County

p. 14, insert: Swink, Floyd, & Gerould Wilhelm. 1979. Plants of the Chicago Region. Ed. 3. Morton Arboretum, Lisle, Ill. lxxiii + 922 pp.

p. 50, insert reference: Wagner, Warren H., Thomas F. Daniel, & Joseph M. Beitel. 1980. Studies on Populus heterophylla in Southern Michigan. Mich. Bot. 19: 269–275.

p. 120, replace parenthetical clause at end of first paragraph as follows: or *Fallopia scandens* (L.) Holub

p. 124, the name at end of the last paragraph should be: *P. maculata* (Raf.) Á. & D. Löve

p. 259, Map 331: add dot in Emmet Co.

p. 335, Fig. 173, add to legend: fruiting twig × ½

p. 433, Map 567: Dot belongs on mainland of Keweenaw Co., not Isle Royale

p. 439, *G. urbanum*: author should be L.

p. 457, Map 601: Dot in southern Michigan belongs in Wayne Co., not Washtenaw Co.

p. 502, *E. cicutarium*: authors should be (L.) L'Hér.

p. 549, line 13: author of the combination as var. *viride* should be E. Murray after the parentheses

p. 581, Map 816: add dot in Houghton Co.

p. 598, *V. odorata:* author should be L.

p. 705: second page number for Gillis should be 533, not 553.

—E. G. Voss

REVIEW

MICHIGAN FLORA Part II Dicots (Saururaceae—Cornaceae). Edward G. Voss. Cranbrook Institute of Science (Bull. 59) & University of Michigan Herbarium, 1985. Bloomfield Hills, Mich. xix + 724 pp., 8 col. pl. $12.50.

This is the second volume of the author's projected 3-volume treatment of the seed-plants of Michigan. The first volume, covering the gymnosperms and monocots, appeared in 1972. The present volume, in Englerian sequence, covers the polypetalous and apetalous dicots. We await the third volume, to cover the Sympetalae. The author also projects a condensed, one-volume manual to appear later.

The outlook and style of presentation are the same as in the first volume, but it will do no harm to review them here. The author provides full, descriptive keys, and frequently extensive taxonomic commentary, but no formal descriptions. References to pertinent taxonomic literature are included. Inclusion of species is based on specimens the author has seen, frequently after diligent search to verify or refute a literature-record. The county-based dot-maps (Michigan only), one for each species, are likewise based on specimens the author has seen. He has chosen to err, if at all, on the side of including doubtfully established species. One individual, not planted, growing without cultivation, is enough. If the species turns out to be a waif in Michigan, no matter; its presence has been noted. There are 8 decorative color-plates (mostly with 6 photos per plate), and 351 line-drawings (borrowed from other sources) designed to aid in identification. The keys are carefully constructed, strictly dichotomous, and (Glory be!) indented.

The presentation reflects the author's careful study of Michigan plants, and his independent judgment at the level of species and infraspecific taxa. The species-concept is a practical one, to which I also adhere: You have to be able to recognize the things consistently by looking at them, if not with the naked eye, then with a hand-lens or standard dissecting-microscope. If taxa are accepted, it means that in Michigan he can tell them apart (with some reservation about *Crataegus,* where it appears that he did not have the courage of his convictions). You can be sure that the measurements are his own, based on field-observation and specimens in Michigan herbaria, not lifted from some other flora or monograph. If the limits of measurement might be different in some other area, so be it; they are right for Michigan.

It is an old in-joke that when taxonomists die they are put to identifying specimens by their own keys. They will soon discover whether they have gone to Heaven or to Hell. There is no question about Ed Voss' destination. His keys work.

The author's nomenclatural skill is well known, as befits the principal editor of the current edition of the International Code of Botanical Nomenclature. He has paid careful attention to getting the right names, under the Code, for the taxa, even at the expense of accepting some unpalatable changes.

The author's view of supraspecific taxa is largely traditional. Familiar, usually fairly broad concepts of genera and families are mostly maintained, under the principle, "If it works, don't fix it". Most users will applaud.

That leads me to an item which only professional taxonomists are likely to care much about. The author chooses to follow the traditional Englerian sequence of families, "not because it is now considered natural, but because (like the traditional tribes in the Gramineae) it is based on easy-to-remember 'key' characters and makes possible ready comparisons among the manuals useful in this region which use the same system". Some botanists were saying the same sort of thing a century and a half ago about the Linnean system. In choosing a general system, the author should be looking to the future (insofar as he can perceive it), not to the admittedly outmoded past. He might have mounted a defense on the basis that it is hard to know which of the modern systems to adopt, but he does not make that argument. I would stake a nickel or so that future floras which might be compared with the Michigan flora will abandon the traditional tribes of grasses as well as the Englerian sequence of families. My own bias in the matter will of course be familiar to many readers of this review.

For many years, Deam's Flora of Indiana was the standard against which other state floras were measured. Now that Dr. Voss has passed the half-way mark, we have a new standard. It is a fine work.—Arthur Cronquist, The New York Botanical Garden, Bronx, NY 10458

ORIGIN AND COMPOSITION OF AN OLD-GROWTH CEDAR-HARDWOOD STAND: THE ROLE OF DUNE ACTIVITY[1]

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From the standpoint of maturity and structure, perhaps the finest known example of upland white cedar (*Thuja occidentalis* L.) forest is found on South Manitou Island in Lake Michigan. South Manitou is the southernmost island of an archipelago located in northeastern Lake Michigan and is situated 11 km to the northwest of Sleeping Bear Point, the nearest mainland. This island served as an important fueling station for Great Lakes steamships and by the turn of the century much of the timber on the island had been cut (Rogers 1966). However, in a survey of the islands of Lake Michigan, Hatt et al. (1948) described a remnant virgin forest of approximately 20 ha on South Manitou, dominated by cedar and hardwoods. On the other hand, Thompson (1963), described the forest as composed almost entirely of cedar, rather than in association with hardwoods. He recorded tree heights in excess of 31 m and estimated the age of one tree to be more than 500 years. Because of the unique status of virgin forests and the apparently contradictory descriptions of this stand's composition, a primary objective of this study was to provide a detailed description of current composition as well as some aspects of stand structure.

In Michigan, the majority of cedar habitat is lowland swamp (Johnston 1977); however, white cedar also occurs along the shore of Lake Michigan from open dunes (Cowles 1901, Wolfe 1932) to protected ravines (Moran 1978). These occurrences are consistent with Olson's (1958) characterization of cedar as an early successional dune species, colonizing damp depressions and lee slopes. Given this role, and the absence of cedar regeneration in the stand (Scott 1984), a second objective of this study was to examine the hypothesis that the present stand of old-growth cedar originated through the colonization of open dune slopes. To test this hypothesis we examined the relationship between the occurrence of cedar and old dune topography within the study area. We also predicted that early stem growth rates of the

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old-growth cedar would be greater than that of cedar which had established under closed-forest conditions, and should be comparable to the early growth of cedar that are currently found on open, lee dune slopes.

METHODS

Forest Composition and Structure

From an initial survey of the southwest corner of South Manitou Island, a study area representative of the mature forest was selected and mapped (Fig. 1). Descriptive information

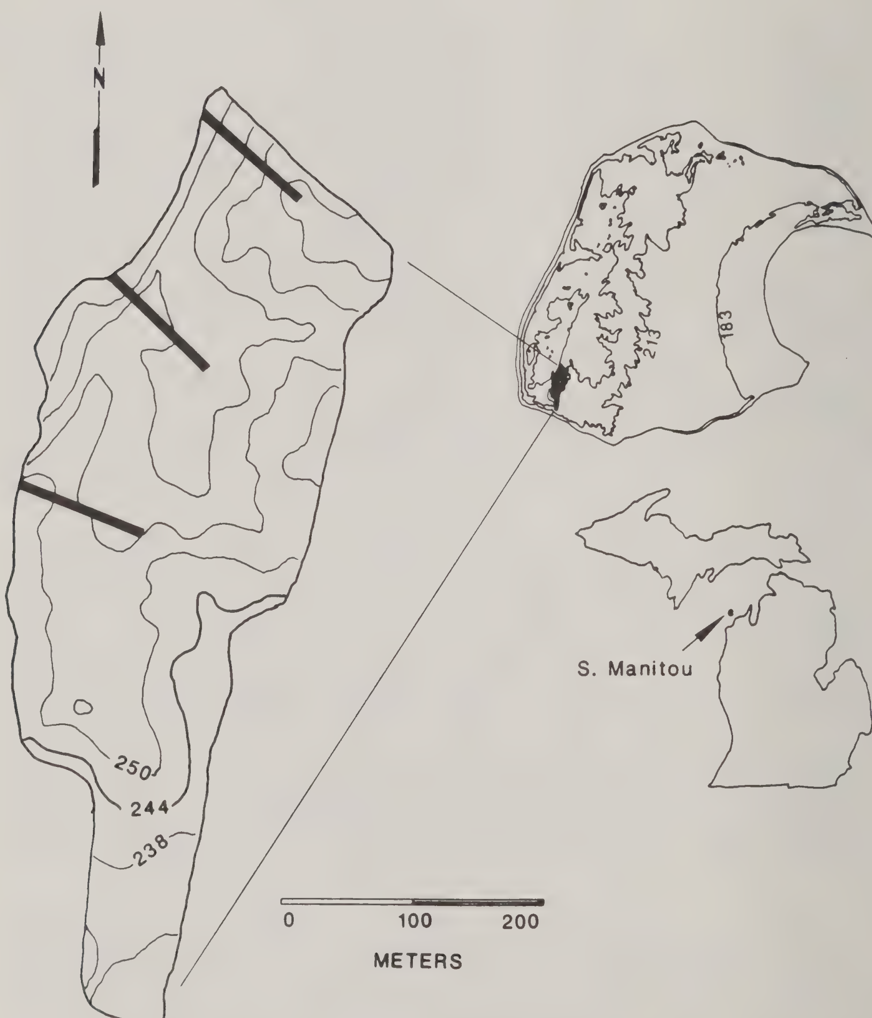

Fig. 1. Location of South Manitou Island and the study area. Contour lines in meters. Dark bands in study area represent location of belt transects.

on the forest was collected from twelve 250-m^2 circular plots. A grid system was established for the site and plot selection was made with the use of a random numbers table. Within each plot the following data were collected on each tree ≥2.5 cm diameter at breast height (dbh): 1) tree species; 2) tree dbh; 3) condition (live or dead); 4) height to top of crown; and 5) crown width in two perpendicular directions. Importance values for all tree species were calculated based upon relative dominance, relative density, and relative frequency (Mueller-Dombois & Ellenberg 1974).

Stand Origin

To determine the occurrence of old-growth cedar relative to dune topography, three 5-m-wide belt transects were established on and perpendicular to a dune crest which defined the western edge of the study area. These transects were extended 120 m into the old-growth forest (Fig. 1). Each transect was marked at 10-m intervals along its length creating a series of 5-m × 10-m plots. Within each plot the number of cedar stems ≥2.5 cm dbh was tallied. Slope angle was measured within each plot with a clinometer to obtain a ground contour along the length of each transect. Estimates of dune slope heights were obtained from the rise and run of each transect, in conjunction with information from a United States Geological Survey (USGS) topographic map of the island. From this information, the frequency of cedar stems relative to dune topography was evaluated.

Additional information on stand origin was obtained from growth analysis of a number of old-growth (N = 11) and sub-canopy (closed forest; N = 10) cedar trees from within the study area, as well as from trees (N = 5) which were found on open dune slopes adjacent to the study area. All trees were selected using a stratified random procedure and were measured for dbh. Increment cores were extracted at breast height, and growth increments over the first 50 years were measured with a tree ring measuring instrument and recorded. Because of the large size of old-growth trees, it was difficult to consistently obtain cores which intersected the center of the tree; however, a comparison of core length to stem radius indicated that all cores passed within eight cm of the center. The number of missing rings from incomplete cores was calculated by dividing the estimated length of missing core by the mean annual increment from the five innermost rings. Finally, average annual increment for the first 50 years of growth was estimated for the old-growth, closed-forest and open dune cedar. Averages were statistically compared using a one-way analysis of variance and Tukey's honestly significant difference procedure (Sokal & Rohlf 1969).

RESULTS

Composition and Structure of the Old-Growth Stand

Of the nine tree species sampled within the study area cedar was the stand dominant, with an importance value of 114 (Table 1). The importance of cedar in the stand was attributable to the presence of a few large individual stems. One cedar tagged by the Michigan Botanical Club measured 162 cm dbh, representing the largest living cedar included in this study. Sugar maple (*Acer saccharum* Marsh.), with an importance value of 77, and white ash (*Fraxinus americana* L.), with an importance value of 41, were important co-dominants, and together with cedar comprised 77% of total stand importance.

There were a total of 884 stems (≥2.5 cm dbh) · ha^{-1} in the stand, 61% of which were between 2.5 and 10 cm dbh, with maple and ash dominating in this size range (Fig. 2 A,C). By contrast, cedar was evenly distributed across a broad size range and accounted for all stems >50 cm dbh (Fig. 2 B).

TABLE 1. Importance values for the old-growth forest.[1]

SPECIES	RELATIVE FREQUENCY	RELATIVE DOMINANCE	RELATIVE DENSITY	IMPORTANCE VALUES	PERCENT OF TOTAL IMPORTANCE
Thuja occidentalis	24	72.5	17.4	113.9	38.0
Acer saccharum	24	15.7	37.7	77.4	25.8
Fraxinus americana	18	8.3	14.7	41.0	13.7
Acer spicatum	16	0.9	6.2	33.1	11.0
Prunus virginiana	4	0.3	4.5	8.8	2.9
Tilia americana	4	1.2	2.3	7.5	2.5
Cornus alternifolia	2	0.2	4.2	6.4	2.1
Ostrya virginina	4	0.2	1.9	6.1	2.0
Abies balsamea	4	0.3	1.1	5.4	1.8
TOTALS				299.6	99.8

[1]Importance Value = (relative frequency) + (relative dominance) + (relative density) (Mueller-Dombois & Ellenberg 1974).

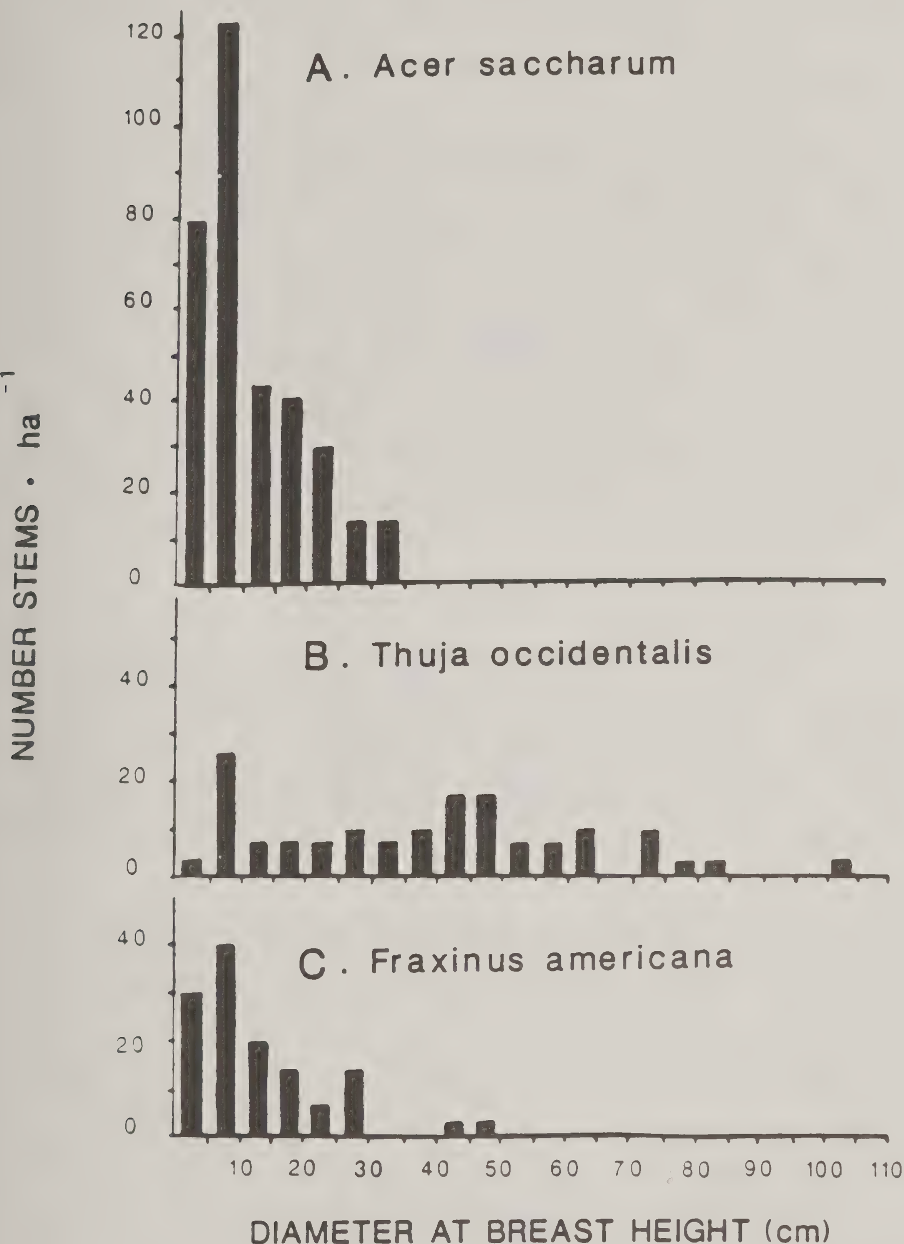

Fig. 2. Stem size class distribution of the three forest dominants.

Despite the large diameters of some cedar within the stand, no trees of any species measured were over 30 m in height and only 5% of all stems were between 20 and 30 m.

Stand Origin

The occurrence of cedar relative to dune topography is illustrated in Fig. 3. Because of the limited number of cedar stems encountered in sampling, a statistical analysis of this relationship was not possible. However, the graphic analysis presents a clear relationship between cedar in transects 1 and 2 and the dune ridge at the western edge of the study area.

Mean annual increment over the first 50 years of growth indicates that following establishment, the present old-growth cedar grew at rates statistically equal to cedar currently growing on the open lee slopes of dunes. In contrast, both old-growth and open-dune cedar had significantly greater rates of growth, over the first 50 years, than smaller diameter cedar which appeared to have become established within the mature stand, i.e., closed-forest trees (Table 2). While tree age was not specifically examined, no old-growth tree in this study approached 500 years of age.

DISCUSSION

The widespread occurrence of maple and ash in the forest presents an impression of stand composition somewhat different than that offered by Thompson (1963). Thompson described the stand as composed of essentially all cedar, based on basal area values from two 25-m × 25-m quadrats. While specific locations were not given for these quadrats, they may have been located in what is now the southern end of the present study area. If sampling were limited to one area of the study site results would not be representative

TABLE 2. F-test[1] and Tukey's honestly significant difference (HSD) test[2] for comparison of mean annual growth over the first 50 years for cedar[3] in three locations.

MEAN ANNUAL GROWTH RATES ($mm \cdot yr^{-1}$)		
Old-Growth Cedar ($N=11$)	Closed-Forest Cedar ($N=10$)	Open-Dune Cedar ($N=5$)
2.19	0.89	2.15

[1]$F=24.3$; $P<0.001$

[2]Means underscored by the same line were significantly different ($P=0.01$) according to Tukey's HSD test.

[3]All trees measured were between 30 and 150 cm dbh.

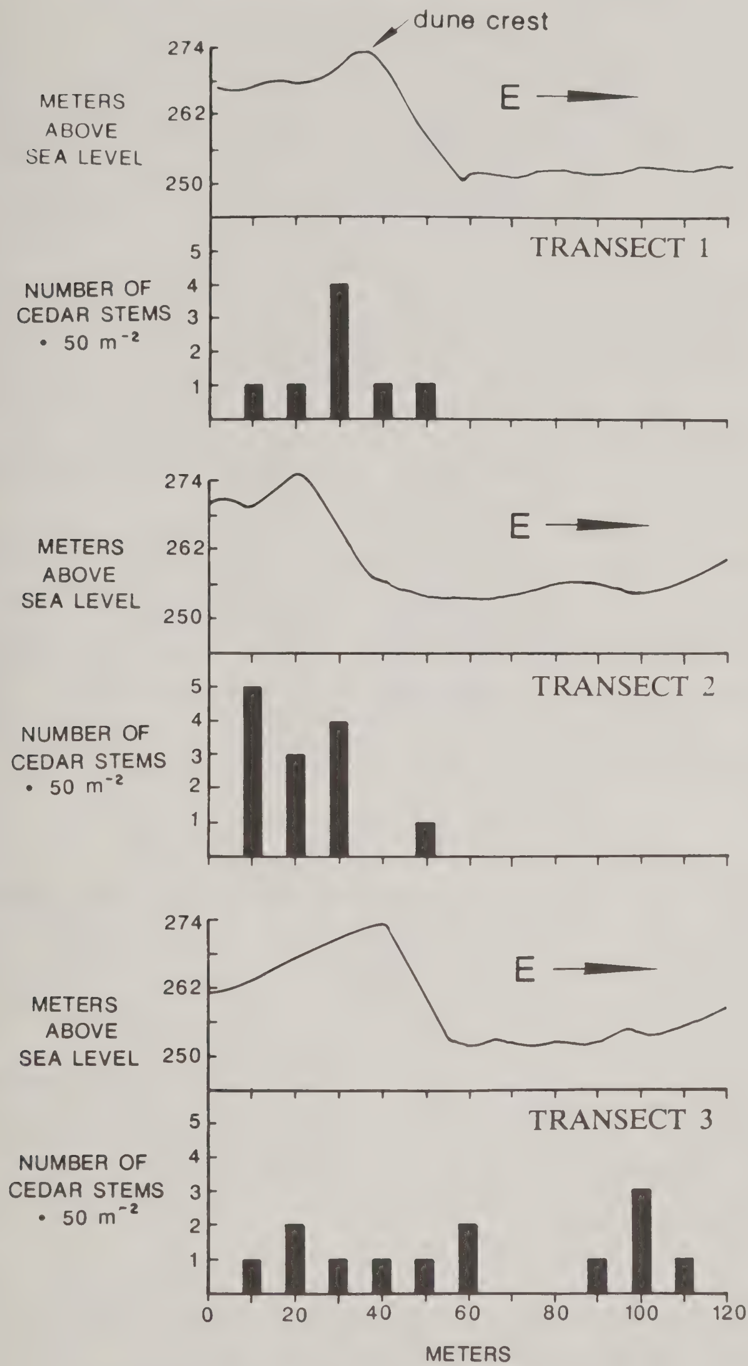

Fig. 3. Distribution of stems in relation to dune topography.

of the old-growth stand as a whole. The results of this study indicate a more compositionally diverse old-growth forest than that reported by Thompson.

Reports of cedar in excess of 31 m in height (Thompson 1963) were unsubstantiated. The tallest live cedar measured in this stand was 24 m and the largest fallen cedar stem measured 26 m in length. These values agree closely with Fowells' (1965) reported height maximum of 25 m. Growth curves for cedar presented by Gevorkiantz & Duerr (1939) suggest that cedar may obtain a maximum height of 23 m on good sites (site index = 40). Overall stature of this forest is smaller than that of mature white pine (as much as 40% less; Rose 1982) or beech-maple (28% less; Murphy & Kroh, unpublished data) and reflects the height maximum for cedar as well as the predominantly small size (<35 cm dbh) of the co-dominants.

A close association was found between the occurrence of cedar and old-dune ridges. The hypothesis that these trees had originally become established on open dune slopes is supported by early growth rates of mature cedar, which were statistically equal to those of cedar currently colonizing the open lee slopes of dunes.

We conclude that stand composition and the observed distribution of cedar in the South Manitou Island stand is a consequence of past dune activity. Development of the present old-growth stand appears to have resulted from the encroachment of a series of dune ridges toward the hardwood forests of the island interior (Rogers 1966), with subsequent regeneration of hardwoods and cedar on the dune ridges. Such a process appears to be taking place in other island locations where cedar is currently becoming established on arrested dune slopes adjacent to old-growth hardwood stands.

SUMMARY

This study provides a description of stand composition and overall structure for an undisturbed, old-growth forest on South Manitou Island, Michigan. The results indicate that large, old-growth cedar presently dominate the stand, and that sugar maple and white ash are important co-dominants. Despite the large diameter of many old-growth cedar (162 cm dbh, maximum), tree height does not exceed 26 m.

Cedar stems in this stand were associated with an old dune ridge and the hypothesis that old-growth cedar became established under open-dune conditions was supported by tree growth analysis. The present forest is thought to have originated when dunes advanced toward hardwood stands of the island interior and were colonized by northern white cedar, as well as hardwood tree species.

A previous study (Scott 1984) suggests that because of limited cedar regeneration in the old-growth forest this species may eventually be replaced in the stand by hardwoods. Thus, the continued persistence and distribution of northern white cedar on South Manitou Island may be disturbance-dependent, reflecting in large part the pattern and extent of future dune activity.

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A PHENOLOGY OF FLOWER COLOR?

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The view of a midwest woods in springtime includes drifts of whitish flowers, while a late-summer open field is yellow with composites. These are common observations, but seldom noted in the recent literature, although Macior (1978) and Schemske et al. (1978) did note that the spring-flowering woodland herbs they studied all had white or pinkish-white blossoms. Older literature does include discussions of blooming seasons and their relation to habitat and flower colors (Robertson 1895, 1924; Kerner & Oliver 1904).

I wanted to find if there are seasonal trends of flower color in the midwest and eastern United States. For a data set I used the information in wildflower books. Since they cover only a portion of the flora (albeit a large number of species), I also used phenological information for a complete flora of a small area.

METHODS

Two sets of wildflower book data were used. The larger data set (''P&M'') is a tabulation from Peterson & McKenny (1968). This reference was chosen because it lists wildflowers by color categories and provides general habitat information and months of bloom. I divided their green category into pale green and green-red (as in Araceae) for a total of seven colors. Within each color category I classed each species as to habitat: mostly open, mostly wooded, or not clearly either. Each species was counted in only one habitat category. I then tallied the number of species in bloom during each month, by color and by habitat category. About 1300 species are included; a few, which Peterson & McKenny placed in more than one color category, are duplicated.

The second wildflower data set, ''Smith'' (from Smith 1966), includes about 390 species of Michigan wildflowers, and gives the Michigan blooming dates to the nearest half-month (e.g., ''late June to early September''). Here, species were tallied under each of their typical habitats; species found in two habitat categories were counted in both (for the P&M data set such plants were counted in the ''not clearly either'' group). Where necessary, flower colors were counted in two separate color categories, but the addition of a white-to-pink category to the seven categories used for the P&M data made this a rare occurance. I tabulated this data set with and without introduced species, but there was little difference so am reporting only the results including them.

I used the two sources and slightly different tabulation methods for confidence that the trends found were not just artifacts of the selection of species by Peterson & McKenny or Smith. To see if the trends of the ''wildflowers'' over a large geographic range were matched by a complete flora of a smaller area, I used the phenological information given by McWilliams & Ludwig (1972) for plants of the Matthaei Botanical Gardens in Washtenaw County, Michi-

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gan. This "M&L" data set includes 313 species and their blooming periods for three years; I arbitrarily chose to use their 1970 data. Flower colors were checked in Smith (1966) or, where necessary, Gleason & Cronquist (1963). The five orange species were omitted.

For each data set blooming curves were made by plotting the number of species in bloom during a time period against time. Thus, a single species is counted for each month (P&M) or half-month (Smith, M&L) it is in bloom. This biologically-reasonable procedure makes the data statistically intractable. However, since the data sets can be considered as data on entire populations (not statistical samples) comparisons need not be statistical.

RESULTS AND DISCUSSION

The blooming curves for the various colors of flowers differ (Fig. 1). The strongest trend, shown in all data sets by both median and peak bloom dates, is that white flowers bloom earlier than yellow flowers. Pink is also early; the P&M pink red (which includes pale pink) and the Smith white-pink is as early as white. The pink-reds of Smith and M&L are later. For all data sets the pink curves are narrower than the yellow and white curves. About equal numbers of blue flowers are in bloom from May through September. Among the less-common colors, pale green and green-red blooms tend to be early and orange blooms late. Put another way, spring-flowering species are mostly white and late summer flowers disproportionately yellow.

Kerner & Oliver (1904) mentioned similar trends for white, yellow, and blue flowers in the Baltic flora. In Illinois, Robertson (1924) found that white flowers peaked about a month before yellow flowers. Apparently these patterns of seasonal color changes are widespread.

A partial explanation is that phylogeny has a strong influence. Using Smith (1966) I found that the median blooming date for all Michigan Compositae is mid-August ($n = 76$) while for all Liliaceae it is late May ($n = 25$). Flower color, as well as bloom date, has a phylogenetic element; 57% of those composites are yellow and 52% of the lily species are white (see also Allen 1882, Robertson 1895, and Gottsberger & Gottlieb 1981). However, even a full consideration of phylogenetic inputs to color and phenology leaves us with the question of why the blooming date of a plant taxon is correlated with its color.

An intriguing possibility involves flowers which have strong contrast (by either strongly reflecting or absorbing) in UV light, as opposed to being UV neutral. Utech & Kawano (1975) suggested that such contrasting flowers in the northern hemisphere would be under selection to bloom in spring, when ozone concentrations are lowest and thus UV light at a seasonal high. They found that many white and yellow flowers were strongly UV contrasting and were spring blooming. My data, though, show white-flowered species blooming earlier than yellow-flowered plants in the midwest. However, I have no specific information on the UV contrast of the flowers considered.

A more likely explanation for this phenology of flower color is that habitat forms a link between blooming date and color. Plants in woods bloom earlier than plants of open places, on the average (Robertson 1895). The data presented here (Fig. 2) are in agreement with Curtis (1959) who found that in

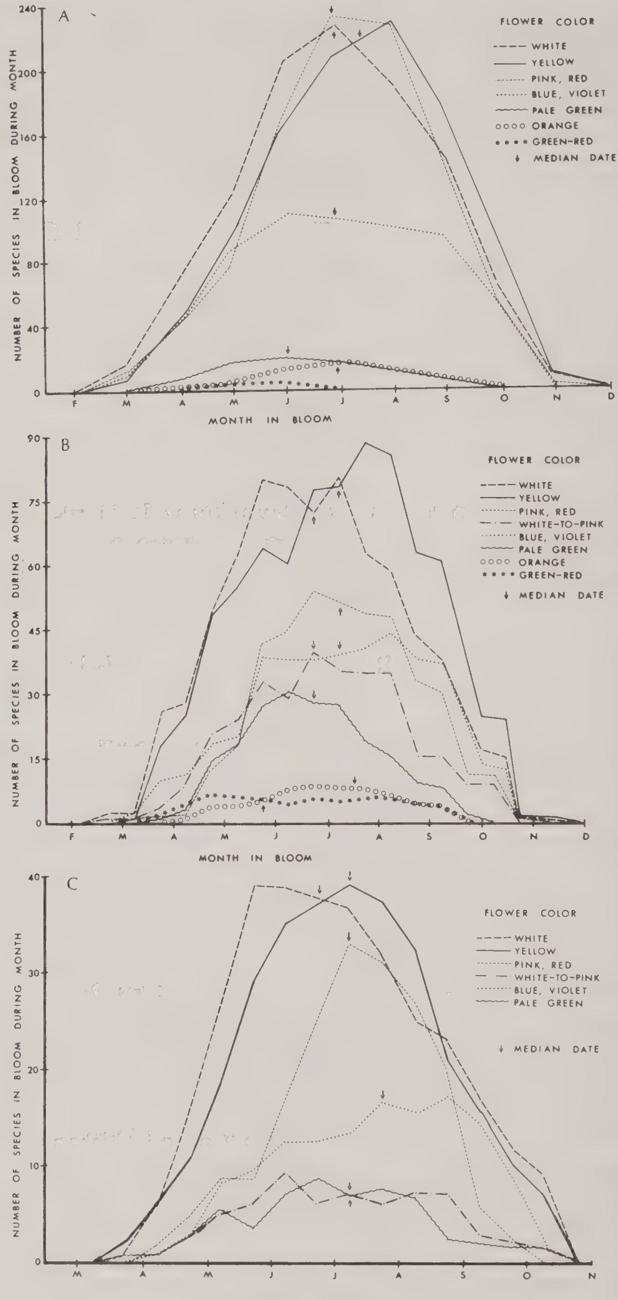

Fig. 1. Blooming curves by color for plants of all habitats in (A) northeast and midwest U.S., P&K data; (B) Michigan, Smith data; and (C) Matthaei Botanical Gardens, M&L data. Ordinal scales differ.

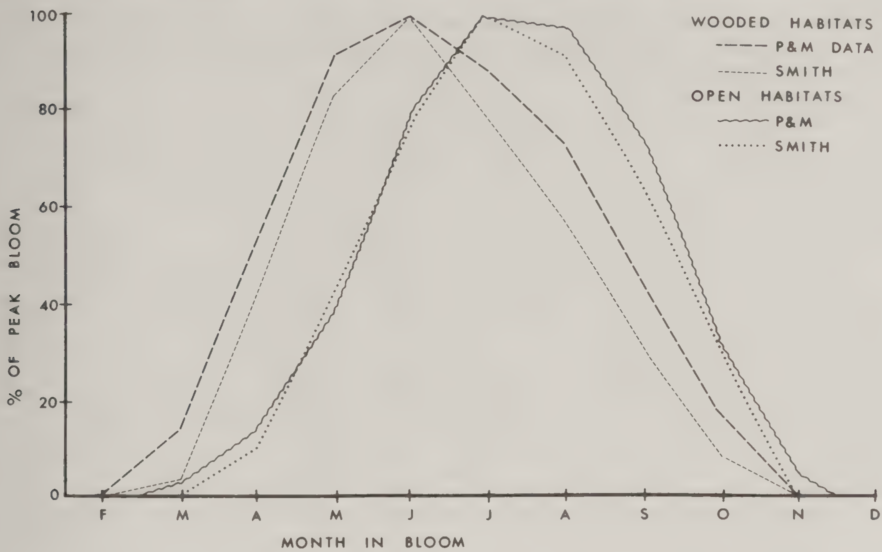

Fig. 2. Blooming curves by habitat for all colors of flowers combined.

Wisconsin over 60% of woodland groundlayer plants flowered before 15 June, while in prairie only a third had blossomed by then. Heinrich (1976), too, pointed out that at his New England woodland site most plants had blossomed before the canopy closed.

Another generality about woodlands is that, compared to open habitats, they include a high proportion of white or pale (light pink, pale green) flowers. This pattern was shown by my data (Table 1) as well as by flower-color data from other areas of the United States (Anderson 1936, Baker & Hurd 1968, Daubenmire 1975, Macior 1978, Ostler & Harper 1978, Schemske et al. 1978). These pale colors generally contrast well against a background of foliage or dark soil in shade or at night (Anderson, 1936; Baker & Hurd, 1968; Mogford, 1978). White flowers in particular are often UV absorptive and contrast well against the usually UV reflecting foliage during the daytime (Frolich, 1976). Kevan (1978) points out, though, that across the insect visible spectrum most flowers (regardless of color) contrast vividly against foliage. The main pollinators of woodland herbs, at least in springtime, are said to be bees and flies, which are diurnal and nearly absent later in the season after canopy closure (Heinrich 1976; Macior, 1978; Schemske et al., 1978). Thus, being seen at night or under a shading canopy seems of little value. However, moths are present in forest from very early springtime and may be doing some pollinating when people are not looking (Baker & Hurd, 1968; R. Brewer, pers. comm.). Paleness may similarly be useful for maximum visibility to any possible pollinator after the canopy closes.

Another possible advantage of pale-colored flowers in woodland is that they may take less energy to construct and maintain than flowers of other colors. I have been unable to find information about the energy costs of

TABLE 1. Flower color distribution (percent) for all species in a flora and for particular habitats. Wooded habitats have a disproportionate number of white flowers.—not tabulated

color	Worldwide (Weevers, 1952)	Northeastern and midwest US (P&M data set) all spp.	Northeastern and midwest US (P&M data set) spp. restricted to open	Northeastern and midwest US (P&M data set) spp. restricted to wooded	Michigan (Smith data set) all spp.	Michigan (Smith data set) spp. found in open	Michigan (Smith data set) spp. found in wooded
white	26.5	27.7	24.1	34.8	27.1	25.0	36.1
white to pink	—	—	—	—	10.6	8.4	16.1
pink, red	15.0	25.6	28.5	23.5	13.3	15.3	5.5
blue, violet	19.5	15.9	16.2	16.2	11.9	14.7	8.2
yellow	31	26.7	28.7	17.9	24.5	31.2	10.2
orange	—	1.5	1.5	1.5	2.1	1.9	0.8
pale green	7.5	2.2	1.0	4.7	7.7	2.2	16.9
green-red	—	0.4	0	1.5	2.8	1.2	6.3

flower pigments; it seems likely that green flowers could be treated somewhat like leaves in energy accounting, and pale flowers probably have less pigment than deeper-colored flowers. The energy savings, although small, might be important where energy is in short supply much of the year. This would be the case for herbs in woods.

For whatever reason, there is a tendency for flowers in woods to be early and whitish, while flowers in open places are more likely to be yellow and bloom late in the summer. Does this combination of habitat-phenology and habitat-color account for the phenology of flower color within broad habitat categories? If so, the blooming curves for the various colors within each habitat would all have the same median and peak as the overall curve (Fig. 2): mid-June in woods and mid-July in open habitats. The height of each color's curve would be determined by the frequency of that flower color in the habitat.

This habitat-color combination does account for some of the overall pattern. For each color, peak and median bloom dates are about a month earlier in wooded habitats. The differences between color curves become less marked but do not disappear. For the P&M data set, yellow flowers are later than flowers of other colors in both habitats (Fig. 3a, 3b). However, in the smaller Smith data set the median yellow bloom (only 17 species) in woods is earlier than the other colors; in open habitats they all have about the same median and peak although the curve shapes are dissimilar (Fig. 3c, 3d). Apparently the habitat-color and habitat-phenology interaction is strong enough to account for much of the overall color-phenology pattern. We are left, then, with the questions of why woodland flowers are pale and why yellow blossoms are more frequent in open areas.

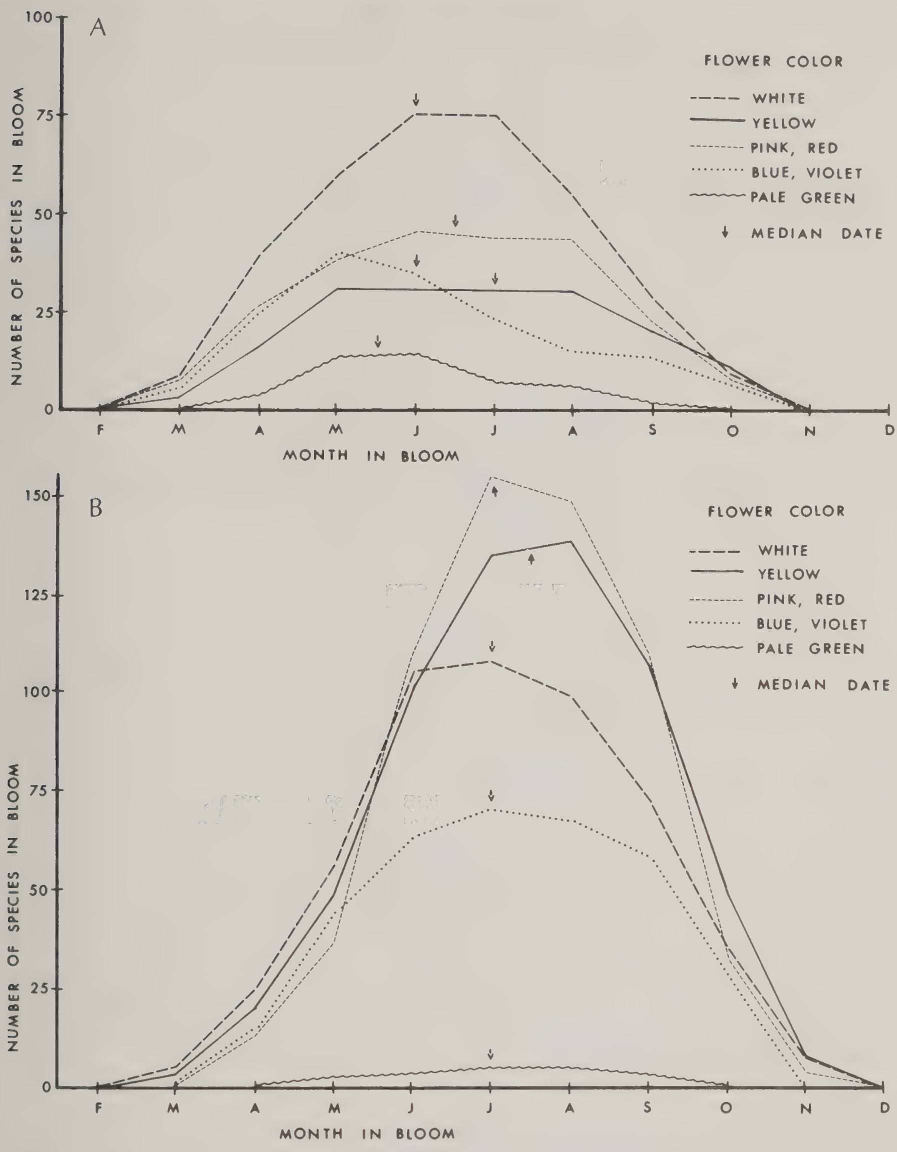

Fig. 3A–B. Blooming curves by color for plants separated by habitat, based on P&K data; plants that are restricted to either woods (A) or open habitats (B) are included.

SUMMARY

Casual observations of the predominance of white flowers in spring and yellow flowers in fall suggested that flowers of different colors may show different phenological curves. Data compiled from two wildflower books and one phenological study show that white and white-

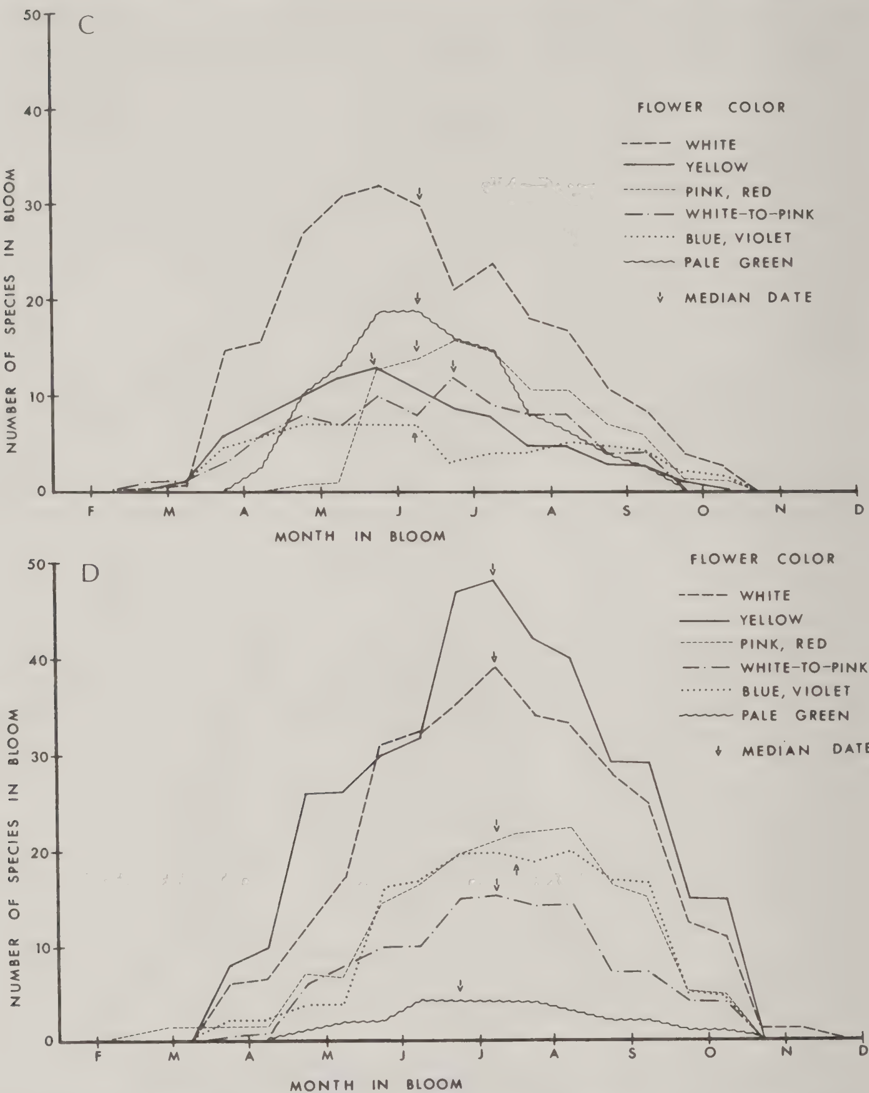

Fig. 3C–D. Blooming curves by color for plants separated by habitat, based on Smith data; plants which are found in (but not restricted to) woods (C) or open habitats (D) are included. Orange and green-red curves were not drawn because in no month were there more than 10 species.

pink flowers blossom earlier than yellow flowers. Also, flowers in wooded habitats tend to be white or light-colored and blossom early, and open habitats include a disproportionate number of yellow flowers and late-bloomers. These habitat factors account for much of the seasonal pattern of flower color.

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THE VEGETATION AND FLORA OF THE NORDHOUSE DUNES, MANISTEE NATIONAL FOREST, MASON COUNTY, MICHIGAN.

I. HISTORY AND PRESENT VEGETATION

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The vegetation of Lake Michigan's sand dunes has fascinated botanists since the early papers of Bailey (1880) and Hill (1893, 1896). Studies subsequent to Cowles's (1899) review of these dunes have described specific areas in greater detail, but most have been concentrated either in the Sleeping Bear region and nearby islands, or in Indiana and southwest Michigan. The floristic and vegetational aspects of the dunes between these centers have not been explored in detail, making the diverse collection of habitats found in the Nordhouse area a prime location for such research. Additionally, as lower Michigan's only proposed wilderness under the U.S. National Forest Service RARE II (Roadless Area Review and Evaluation) program, a greater understanding of the natural history of the Nordhouse Dunes could contribute to the preservation of this area and aid in its subsequent management.

In the early 1970s the beauty of the open dunes and their fragile habitats were threatened with destruction by the use of ORVs. This threat has been abated, but recent seismic exploration by petroleum companies has cast another shadow on the preservation of this area.

The floristic diversity and wilderness potential of the Nordhouse region was first described by Hazlett (1981). This paper describes the region's history and present vegetation. A second paper, dealing primarily with the flora, will include a list of vascular plant species (Hazlett, 1986).

GENERAL DESCRIPTION

The Nordhouse Dunes occupy 3514 acres of Grant Twp. (T 20 N, R 18 W), Mason Co., Michigan. This area (Figures 1 and 2) lies completely within Manistee National Forest and is bounded by Ludington State Park on part of its southern boundary. Approximately three miles of Lake Michigan shoreline form its western boundary. The northern boundary is formed by the north section line of Secs. 25 and 26 until meeting and then following Forest Road (FR) 5629. FR 5356 marks the eastern boundary. Nurnburg Rd. delimits much of the the southern boundary. The boundary of the study area then follows the old powerline clearing in Sec. 34 until reaching and then following the south section line of Secs. 32, 33, and 34.

Fig. 1. Aerial photograph of the Nordhouse Dunes, 1972 (ASCS-USDA).

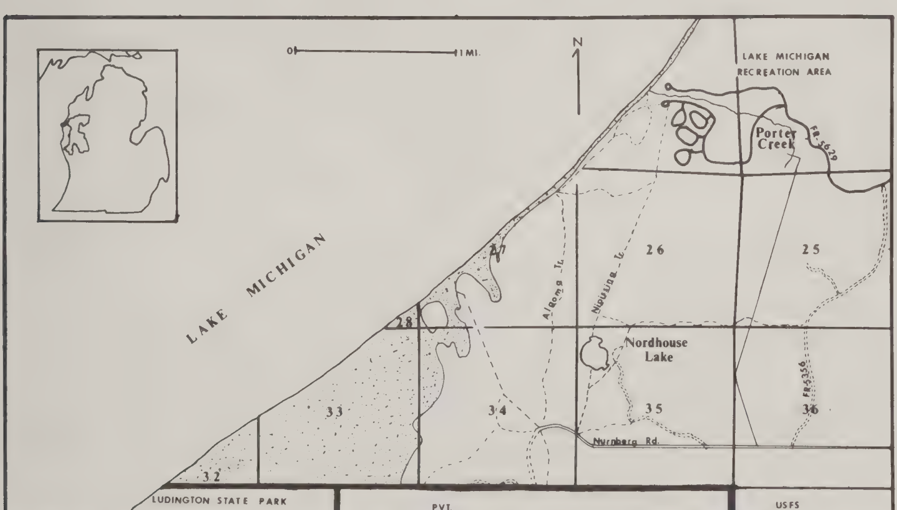

Fig. 2. Map of roads, trails and physical features of the Nordhouse Dunes. Stippling shows open sand. Inset shows location of area within Manistee National Forest and the state of Michigan.

Originally 2879 acres of public land in this area were reviewed under RARE II by the Forest Service in 1978. In addition, this study also includes 556 acres of inholdings adjoining this tract (Secs. 32, 33, and 40 acres of Sec. 31) purchased by the Nature Conservancy in 1979. This land was later transferred to the Forest Service when federal funds became available. About 31 acres including the cedar swamp between Nurnburg Rd. and the old powerline clearing (Sec. 34 SW ¼) and 5 acres of dunes (Sec. 28) bordering the proposed wilderness were also included within this floristic survey.

CLIMATE

Weather records from both Ludington, 10 miles to the south, and Manistee, 10 miles to the north, show the ameliorating effect of Lake Michigan on the shoreline climate. Generally the prevailing westerly winds induce cooler spring and early summer temperatures than would normally be expected at this latitude (44° 5′ N). Conversely, the winters are milder. Easterly or northeasterly winds may be accompanied by clearing skies with the associated colder nighttime temperatures more common inland. The influence of Lake Michigan is illustrated by the number of days showing temperature extremes. Both the annual averages for the number of days less than 0° F and those greater than 90° F are less than five. Other weather records are listed in Table 1.

GEOLOGY AND PHYSIOGRAPHY

Around 12,000 before present (B.P.), the Port Huron glacial lobe covered the Nordhouse area. With the retreat of this lobe to the Manistee moraine, 9 miles to the north, the waters of

TABLE 1. Selected weather records for Ludington and Manistee, Michigan, 1940–1969 (Michigan Weather Service)

Record	Ludington	Manistee
record high t	97° F	100° F
record low t	−21°F	−29° F
ann. ave. ppt.	31.30 in.	31.03 in.
wettest month (ave.)	Sept. 3.38 in.	Sept. 3.57 in.
driest month (ave.)	March 1.73 in.	Feb. 1.62 in.
ave. ann. snowfall	72.0 in.	81.7 in.
record high snowfall (season)	128.6 in. (1958–59)	134.2 in. (1958–59)
record low snowfall (season)	39.4 in. (1943–44)	37.8 in. (1960–61)
freeze-free period (growing season)	167 days	153 days

the Glenwood stage of Lake Chicago inundated the area (Farrand & Eschman 1974). The clay pan presently underlying the study area may have formed at this time. The Glenwood stage (660′ el.) was followed by the Calumet stage (620′ el.) The present Nipissing ridge may rest on the fossil beach formed during this stage (Evenson et al. 1973). The levels in the Lake Michigan basin then fluctuated greatly as the ice margin advanced and retreated during the subsequent deglaciation of Michigan. By the time of Lake Algonquin (605′ el.; 10,000 B.P.), the area now east of the Nipissing ridge was probably a series of open dune ridges and dune pools. Next, as the water level dropped due to lower outlets opened by retreating ice margins and erosion to form Lake Chippewa (235′ el.; 9,500 B.P.), the entire study area and much of the Algonquin lake bed were open to colonization by arboreal species. These forests were subsequently covered by dunes or drowned by Lake Nipissing (605′ el.) as isostatic rebound between 9,500–4,000 B.P. raised the North Bay outlet of Lake Chippewa. Subsequent downcutting of the Port Huron outlet brought the levels of Lakes Huron and Michigan to their present altitude via the Algoma stage (595′ el.; 2,000–3,000 B.P.).

Stream valleys which had been graded to the Chippewa level were drowned by the rising Nipissing waters and occasionally were cut off from the main lake by the construction of bay-mouth bars and spits. Hamlin Lake, just south of the study area, was formed as receding lake levels exposed Big Point Sable (Dorr & Eschman 1970). As this point emerged, the center of active dune movement shifted away from the Nordhouse area.

Physiographically, the area can be roughly divided into three parts: the marginal dune apron; the wooded dune ridges; the open dunes. The marginal dune apron, occupying much of the eastern part of the study area, is predominately glacial outwash which has been reworked by high glacial lake levels. The wooded linear dune ridges are Nipissing and Algoma formations (Watson 1976) which transect the study area from north to south. The open dunes to the west are a complex of numerous irregularly arranged dunes generally of low relief with scattered intertwining ridges. The highest dunes in this area border the wooded dunes and rise to a height of 160 ft. above Lake Michigan. Blowouts are a common feature in Sec. 27. The largest extends slightly less than .75 miles inland and attains a height of 140 ft. above the lake.

SOILS

The soils throughout the region (Figure 3) are predominately composed of sand (Wonser et al. 1939). The marginal dune apron is largely mapped as Rubicon fine sand, Newton loamy sand, and Saugatuck sand. Rubicon fine sand is an excessively well drained spodosol while Saugatuck sand is a somewhat poorly drained spodosol with an ortstein layer. Newton loamy sand is a poorly drained inceptisol with a pH less than 5.6. The wooded linear dune ridges are mapped as Bridgeman fine sand and are well drained. Dune sand composes the open dunes. Some histosols (Lupton muck, Rifle peat, and Greenwood peat) have developed in wet depressions where organic matter could accumulate.

PRESETTLEMENT VEGETATION

The Nordhouse area is too small to provide a quantitative analysis of the presettlement forest based on the 1839 General Land Office Survey notes (available at the Lands Division of the Department of Natural Resources, Lansing) recorded by John Mullet and John Brink. A general description, however, may be inferred. The summary description from east to west along the south section line of Secs. 34, 35, and 36 reads, ‘‘land rolling, third rate, hemlock, pine, beech, maple, and sugar.’’; along the south section line of Secs. 25, 26, 27, and 28, ‘‘land level, tamarack and cedar swamp; land rolling second rate except for swamp and sand hills, white and yellow pine, hemlock, beech and oak.’’; along the north section line of Secs. 25, 26, and

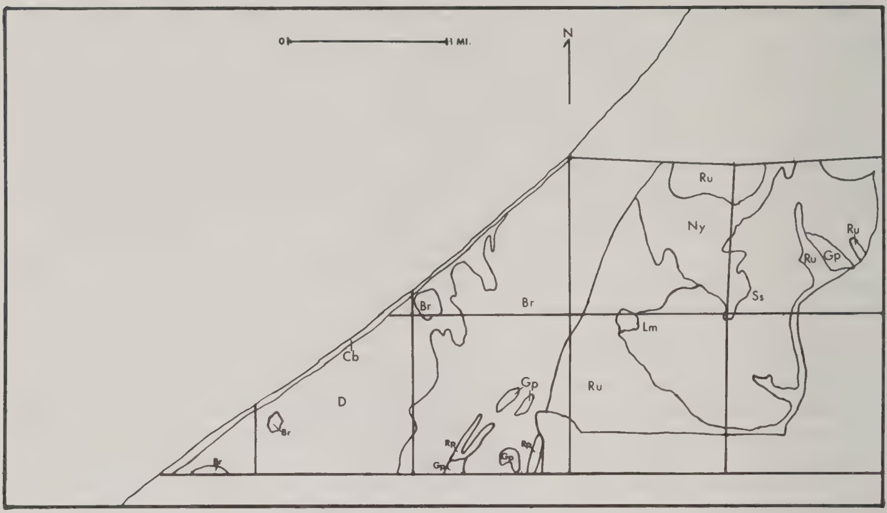

Fig. 3. Soil map of the Nordhouse Dunes adapted from Wonser et al. (1939); Br, Bridgeman fine sand; Cb, coastal beach; D, dune sand; Ny, Newton loamy sand; Ru, Rubicon sand; Ss, Saugatuck sand; Gp, Greenwood peat; Lm, Lupton muck; Rp, Rifle peat.

27, "land mostly swamp, tamarack, cedar, oak and hemlock; land rolling second rate and thinly timbered with yellow and white pine and oak." For this part of Michigan, yellow pine usually denotes *Pinus resinosa;* cedar, *Thuja occidentalis;* maple, *Acer rubrum;* sugar, *Acer saccharum* (Griffin, no date). The three major presettlement forest types, therefore, are a mixed pine forest with oak understory on much of the forested dune ridges, a northern hardwoods forest on the moist upland ridges of the sand apron to the east, and a wet *Larix-Thuja* forest in the lowland sites of the sand apron. To the west of the forested dune ridges was open sand predominately vegetated by grasses.

HUMAN HISTORY

The north shore of Hamlin Lake has been described as the summer site of Huron Indians (Fitting 1967, 1975). Janet G. Brashler, Forest Service archeologist, (pers. com.) relates, "it is clear that Indian people were living along the shore of Lake Michigan and Hamlin Lake at least as far back as 2500 B.C., and almost certainly several thousand years earlier. Some of the village and/or campsites were located on post-pleistocene beach ridges and possibly on the backsides of related dunes. . . . We know that Indian people continued to live in the area throughout the first millenium A.D. and into the historic period in the 17th and 18th centuries. . . . During the early historic period Ottawas, Chippewas, and possibly Algonkian speaking peoples lived and travelled in the general area of the Nordhouse dunes."

The presettlement forest was lumbered in the late 1800s. At this time the

land was owned by R. G. Peters, "king of the lumbermen", who in his zeal for a profit "became the owner of perhaps the largest quantity of pine stumpage that was held by any individual in the state of Michigan" (Hochkiss 1898). The remains of a narrow gauge railroad can be followed from Lake Michigan Recreation Area campground to Nordhouse Lake along the east edge of the Nipissing ridge. Charred stumps abound throughout the study area suggesting widespread fires after logging.

According to Forest Service compartment records, the earliest years of stand origin date from the late 1800s. These stands (Figure 4) occur along the Algoma and Nipissing ridges and a short distance into Sec. 26. The oldest year of stand origin, 1878, is recorded for the deciduous vegetation "island" surrounded by sand in Sec. 27 SW ¼. Evidence of logging has not been found here although some stumps have been found on the islands of deciduous trees in Sec. 33. The most recent lumbering in the study area, a 32 acre clearcut just north of the red pine plantation in Sec. 35, was done in 1977.

ADMINISTRATION

Much of the land within the recommended RARE II wilderness was acquired by the Forest Service during the 1930s and 40s. A large portion known as the Porter-Mulder tract was purchased in the early 1960s. Plans for a recreation area were drawn soon thereafter, including a visitor center, swimming pool, enormous campground facilities, and an elaborate trail system. Later these plans were scaled down to the present campground and

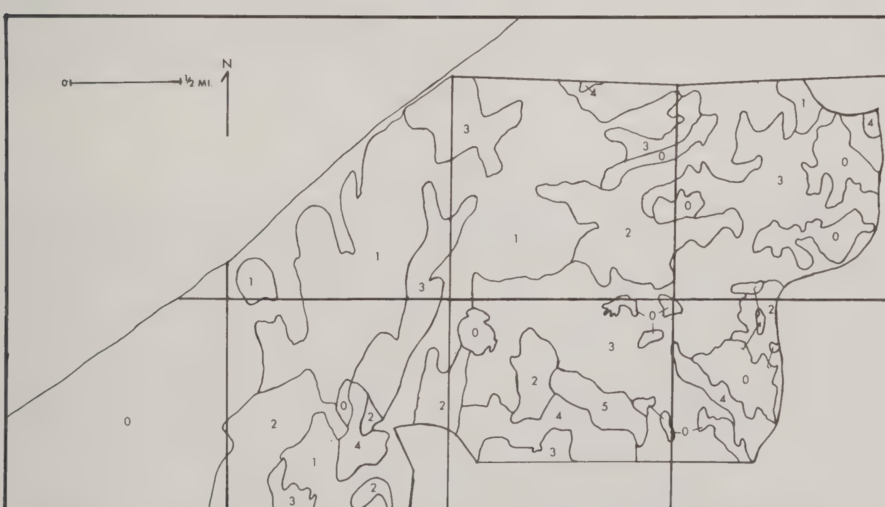

Fig. 4. U.S. Forest Service records for year of stand origin: 1, pre-1900; 2, 1900–1919; 3, 1920–1939; 4, 1940–1959; 5, 1960–1979; 0, no date.

picnic area. During the late 1960s and early 70s the open dunes at Nordhouse became a popular attraction for ORV operators. The area around Nordhouse Lake was subsequently used as a campground. An estimated average of 50 ORVs could be found on the dunes as well as 200 vehicles at the end of Nurnburg Rd. during peak periods (USDA 1976). In 1973, the Forest Service closed the dunes to motor vehicles to conduct a study to determine the extent of any deleterious effects on the dunes from ORV use. The study (USDA 1976) concluded that the dunes should remain closed to motorized vehicles in order to stop the excessive use of the land around Nordhouse Lake, to retard the deterioration of the dune formations, to prevent erosion of trails, to end any damage to private property, and to eliminate the danger of ORV related accidents. Barriers were erected and notices of the restricted area were posted around its perimeter.

The management of the Nordhouse Dunes Wilderness, which would include the Nature Conservancy purchase, would not differ significantly from the area's management before the RARE II process. Wilderness management would prevent any timber harvesting or stand improvement and those areas off limits to motor vehicles would be expanded from the dune formations closed in 1973 to include the entire proposed wilderness. Hunting and dispersed camping would still be permitted. Congressional approval is needed before a wilderness designation is official, but until that time the Forest Service is managing the area as if it had such designation.

When the Porter-Mulder tract was purchased by the Forest Service, the subsurface mineral rights were retained by the previous owners. In 1983 Miller Brothers Oil Corporation signed an oil and gas lease on this 1497 acre tract. About 1029 acres of this land, largely the area now occupied by the wooded Nipissing and Algoma dune ridges, occur within the proposed RARE II wilderness. In early 1984 seismic testing within the leased area was permitted by the Forest Service. The specific results of these tests have not been made public, so the future of the Nordhouse Dunes as far as oil drilling and extraction are concerned is unclear.

METHODS

Field work for this study was begun in 1979. Three early trips (5/5, 5/19–21, 6/8–10) to the Nordhouse area were made to document the vascular plant flora. Then from June 28 until August 27 I camped at Lake Michigan Recreation Area campground and continued intensive collecting. The final collecting trip of 1979 was made in September (21–23). A few additional specimens were collected in the following year (6/10–15). Vouchers were deposited in the Beal-Darlington Herbarium, Michigan State University (MSC) and in the University of Michigan Herbarium (MICH) in cooperation with the Michigan Flora Project. In rare cases when only one specimen of a species was collected, that specimen was deposited at MSC.

Data on the species composition of the various vegetation types were gathered during July and August using the releve method of Braun-Blanquet as described by Mueller-Dombois & Ellenburg (1974). This method aptly fit the varied pattern of the Nordhouse vegetation, and the final vegetation map based on this analysis could be directly compared to previous timber mapping by the Forest Service. The detailed species lists made for each releve also facilitated a floristic comparison among the various vegetation types. The open sand, bogs, alder thickets, and ponds, however, were not analyzed by this method, but were instead described from field observations and collections made in these areas.

Aerial photographs of the Nordhouse area were used extensively in determining the boundaries of the vegetation types and in locating sites where releves could be run. A preliminary vegetation map was first drawn using 1973 ASCS black and white (1 in. = 600 ft.) aerial photography as a base. Ground verification later confirmed that each type had an identifiable shade and texture in these photographs. Thirty-seven releves, most with a minimal area from 200–400 square meters, were used to gather data from which descriptions of the types could be written. After several stands were releved, some unreleved stands, determined by field observations and aerial photographs as being similar to releved stands, were also mapped.

In this study the initial plot of a releve was 100 square meters (10 m × 10 m). The area of this plot was successively doubled in a nested fashion until minimal area (determined by the asymtotic levelling of the species/area curve or the absence of any new species as plot size increased) was reached. Once minimal area was reached, each species in a releve was listed as being a tree, sapling, shrub, or herb. A qualitative value of the cover of each species in the releve was then assigned. The cover of herbs, shrubs, and saplings (dbh < 5cm) was estimated in the field by visually comparing the cover of each species to the size of the releve. The cover of trees (dbh > 5cm), however, was determined by calculating the total basal area of each species. The following cover-abundance scale was applied to each species:

5, any number of individuals with a combined cover greater than 75 percent.
4, any number of individuals with a combined cover of 50–75 percent.
3, any number of individuals with a combined cover of 25–50 percent.
2, any number of individuals with a combined cover of 5–25 percent.
1, few individuals with a combined cover from 1–5 percent.
+, few individuals with a combined cover less than 1 percent.
r, species occurring only once.

The data from all releves were compiled into one table. Constancy values, the percent of releves in which a given species was found, were then calculated for each species. Species with the highest constancy are listed in Table 2. Species which could be used to differentiate one vegetation type from another were sought from those having intermediate constancy (10–60%). Ideally, species of intermediate constancy should be used as differentiating species; however, in this study a large cover rating (4 or 5) of *Acer rubrum* (73% constancy) was used in differentiating the lowland hardwood and mixed deciduous forest types from the others. Similarly, the oak and aspen forest types were separated from the rest by a large cover rating (4 or 5) of *Pteridium aquilinum* (65% constancy). Later both the lowland and mixed deciduous forest types, and the oak and aspen forest types were then separated by other differentiating species. A final grouping of releves of the same type was made and the preliminary vegetation map was modified in accordance to this arrangement.

TABLE 2. Constancy values (%) of the most common species encountered during releve analysis of wooded areas

Species	%	Species	%
Acer rubrum	73	*Pinus strobus*	32
Gaultheria procumbens	65	*Fagus grandifolia*	30
Pteridium aquilinum	65	*Gaylussacia baccata*	27
Betula papyrifera	57	*Viburnum acerifolium*	24
Maianthemum canadense	54	*Cornus canadensis*	22
Mitchella repens	49	*Dryopteris spinulosa*	22
Trientalis borealis	49	*Epigaea repens*	22
Vaccinium angustifolium	49	*Tsuga canadensis*	22
Populus grandidentata	46	*Quercus alba*	19
Quercus rubra	46	*Viola* sp.	19

DESCRIPTION OF THE VEGETATION

The final vegetation map for the Nordhouse study area is depicted in Figure 5. Descriptions of each vegetation type were drawn from field observations and the releve data from that type.

Open Dunes (D)

The open dunes of Secs. 27, 28, 32, 33 include the beach, foredune, blowouts, and dune ridges. Jack pine stands and dune pools interrupt the open sand in Secs. 32 and 33. Hardwood forests border the open dunes on the south and east. The dunes seem to be invading these forests in Sec. 33 E ½. Here sand is creeping into the forest and the tops of dead trees can be observed near the crest of the lee slope. The rate of movement may have slowed because oak and maple seedlings had become established on this slope. At the time of these observations, the main direction of sand movement on the open dunes was north rather than east. One such active dune in Sec. 27 W ½ was once a stabilized dune ridge, but ORV use had removed enough vegetation to renew sand movement.

Grasses are the dominant cover of the open dunes. *Ammophila breviligulata* is common in disturbed areas such as dune crests and on the edges of moving dunes and blowouts. *Calamovilfa longifolia* and *Andropogon scoparius* are common on the stable lee sides of dune ridges and on the foredune. Woody species are most common along and just behind the foredune. These

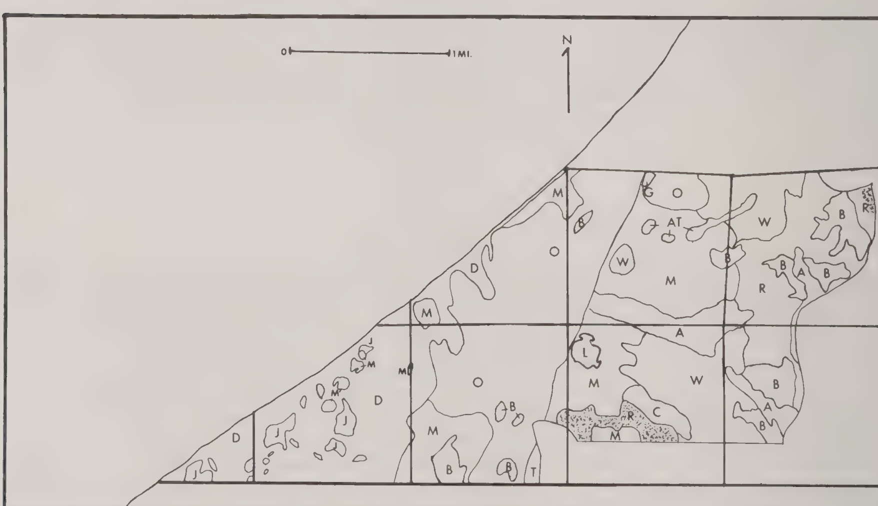

Fig. 5. Map of current vegetation of the Nordhouse Dunes: A, aspen; AT, alder thickets, marshes, and ponds; B, bog; C, clear-cut; D, open dunes; G, meadow; J, jack pine; L, Nordhouse Lake; M, mixed deciduous woods; O, oak woods; R, red pine; T, cedar swamp; W, lowland hardwoods; stippling, planted conifers.

include *Cornus stolonifera, Hypericum kalmianum, Juniperus communis, Prunus pumila, Rosa blanda, Salix cordata, S. exigua,* and *Toxicodendron radicans*. Herbs generally most common on the beach and foredune areas include *Asclepias syriaca, Cakile edentula, Campanula rotundifolia, Equisetum arvense, E. hyemale, Oenothera oaksiana, Solidago spathulata, Smilacina stellata,* and *Zigadenus glaucus*. *Populus balsamifera* is most common along the foredune while *P. deltoides* occurs in greater numbers on stablized dunes farther from the lakeshore. Herbs appearing more frequently on blowouts and open dunes include *Cyperus schweinitzii, Hudsonia tomentosa, Koeleria macrantha,* and *Polygonella articulata*. Species common throughout the open dunes include *Artemisia caudata, Cirsium pitcheri, Elymus canadensis, Euphorbia polygonifolia, Lathyrus japonicus, Lithospermum caroliniense,* and *Monarda punctata*.

Dune Pools and Pannes

No streams enter Lake Michigan within the study area, but local wet sites, dune pools and pannes, occur on the dunes in Secs. 32 and 33 due to the close proximity of the water table. Dune pools have an average depth of 3–6 inches of standing water with the vegetation usually confined to the outside edge. A few species here include *Lobelia kalmii, Potentilla anserina,* and *Senecio pauperculis*. *Cyperus americanus, Juncus balticus,* and *Triglochin palustre* are common emergents. Dune pannes are dune pools that are filled by moving sand yet remain moist. *Salix exigua* and *S. lucida* are common woody species. Grasses such as *Panicum virgatum* and *Agrostis hyemalis* and sedges such as *Carex viridula* and *Eleocharis elliptica* are frequently found. Other herbs include *Equisetum arvense, E. hyemale, Eupatorium perfoliatum, Rudbeckia hirta,* and *Solidago graminifolia*. Some of these sites have probably succeeded to jack pine stands.

Jack Pine Stands (J)

Jack pine stands develop on dune pannes and around dune pools. This vegetation type is hard to describe because the boundaries of these stands are not well defined and moisture conditions are not constant from stand to stand. *Pinus banksiana* cover is generally almost 100 percent although a few small *Thuja occidentalis* and *Betula papyrifera* are found. Other woody species occurring in these stands include *Arctostaphylos uva-ursi, Juniperus communis, Salix discolor, Shepherdia canadensis, Toxicodendron radicans, Vaccinium macrocarpon, Viburnum acerifolium,* and *Vitis riparia*. Herbs include *Anaphalis margaritacea, Antennaria plantaginifolia, Fragaria virginiana, Linnaea borealis, Melampyrum lineare, Moneses uniflora, Pyrola elliptica, Smilacina stellata,* and *Spiranthes cernua*. A few species limited only to these stands include *Chimaphila maculata, C. umbellata, Cypripedium arietinum, Goodyera oblongifolia* and *Linum striatum*.

These stands have the potential to develop into deciduous forest stands, but are probably limited in their succession by moving dunes as regional

wind patterns change. One place where a jack pine stand may have succeeded to a deciduous stand is the vegetation "island" (Figure 5) of Sec. 27. The soil age suggests that the forest of this island arose on the dunes rather than being cut off from the mainland by a blowout (Watson 1976).

Oak Woods (0)

The forest occupying much of the Nipissing and Algoma ridges is dominated by three *Quercus* species. The combined cover of *Q. alba, Q. rubra,* and *Q. velutina* is usually over 50 percent throughout this forest type, but the distribution of these species is not random. *Quercus alba* is most common in the low interdunal sites. *Quercus velutina,* in contrast, is most common along the crests of the dune ridges. *Quercus rubra* is generally well distributed throughout the oak type and even occurs in the moist deciduous woods. Trees with secondary cover values include *Acer rubrum, Betula papyrifera, Hamamelis virginiana, Pinus banksiana, P. resinosa, P. strobus, Populus grandidentata,* and *Sassafras albidum. Betula papyrifera* and *A. rubrum* are most common where the oak woods border the open sand. Some pine and aspen inclusions also occur here. The 5–25 percent cover of young *Pinus strobus* trees throughout the oak woods suggests a possible succession to a white pine forest similar to the presettlement forest. The canopy of the present forest is open allowing extensive undergrowth development. The cover of both *Gaylussacia baccata* and *Pteridium aquilinum* is usually at least 50 percent. *Vaccinium angustifolium* and *V. myrtilloides* are easily found. Herb layer species include *Carex pensylvanica, Conopholis americana, Cypripedium acaule, Deschampsia flexuosa, Epigaea repens, Gaultheria procumbens, Houstonia canadensis, Maianthemum canadensis, Melampyrum lineare, Mitchella repens, Pedicularis canadensis,* and *Trientalis borealis*. Some species found only in this forest type include *Diervilla lonicera* and *Taenidia integerrima*.

Mixed Deciduous Woods (M)

A mixed deciduous forest occupies the moist sites of the Algoma and Nipissing ridges and the upland sites of the marginal dune apron. Generally *Acer rubrum* has a cover value between 50–75 percent in which other trees of widely varying cover such as *Betula papyrifera, Fagus grandifolia, Quercus rubra,* and *Tsuga canadensis* are found. Less common trees include *Pinus resinosa, P. strobus, Populus grandidentata, Prunus serotina,* and *Betula alleghaniensis. Acer saccharum* is not common in the these woods and is only found in a small, but rich upland area in Sec. 26 SE ¼. Other species limited to this upland area include *Lycopodium annotinum, Erythronium americanum, Hepatica americana,* and *Osmorhiza claytonii*. The entire mixed deciduous woods is characterized by dense shade which prevents an extensive development of a shrub layer. The herb layer, however, is rich with species such as *Aralia nudicaulis, Athyrium filix-femina, Circaea alpina, Cornus canadensis, Epifagus virginiana, Epigaea repens, Galium triflorum,*

Gaultheria procumbens, Lycopodium clavatum, L. complanatum, Maianthemum canadensis, Mitchella repens, Monotropa hypopithys, Oryzopsis asperifolia, Trientalis borealis, and *Viola cucullata. Goodyera pubescens* and *Botrychium matricariifolium* are a few other noteworthy species occurring only in this forest type.

A diverse flora occurs where the mixed deciduous woods occupies the bank behind the foredune in Sec. 27 and the remnants of this bank occupied by deciduous forest islands in Secs. 27 and 33. Perhaps the floristic diversity of these sites is due to the increased soil moisture from the underlying clay pan and to the edge effect created by the closeness of the forest to the foredune and open sand. Tree species here include *Acer rubrum, Betula papyrifera, Fraxinus pennsylvanica, Ostrya virginiana, Pinus resinosa, P. strobus, Quercus rubra,* and *Thuja occidentalis.* Woody understory species such as *Lonicera canadensis, L. dioica, Shepherdia canadensis, Taxus canadensis, Toxicodendron radicans,* and *Viburnum acerifolium* can be found. The herb layer is very rich with *Actaea pachypoda, Aquilegia canadensis, Aralia nudicaulis, Aster macrophyllus, Botrychium virginianum, Circaea alpina, Clintonia borealis, Corallorhiza trifida, Cynoglossum boreale, Equisetum arvense, E. hyemale, Galium triflorum, Maianthemum canadense, Moneses uniflora, Polygonatum pubescens, Polypodium virginianum, Pyrola asarifolia, P. secunda,* and *Trientalis borealis.*

Lowland Hardwoods (W)

The lowland hardwoods forest is most extensive on the marginal sand apron east of the Nipissing ridge. The occurrence of wet sites which favor this forest is in part due to the underlying clay pan in these areas. In the spring these woods are flooded. A distinguishing character of this lowland forest is an *Acer rubrum* cover of at least 75 percent. Other common forest trees include *Betula papyrifera, Fraxinus pennsylvanica,* and *Populus grandidentata. Acer spicatum, Ilex verticillata,* and *Vaccinium myrtilloides* are woody understory species. A second character defining this forest type is a cover of at least 25 percent for either *Osmunda cinnamomea* or *Onoclea sensibilis.* Other herbs of lesser cover value include *Arisaema triphyllum, Boehmeria cylindrica, Carex crinita, Circaea alpina, Dulichium arundinaceum, Galium triflorum, Glyceria canadensis, Habenaria clavellata, Mimulus ringens, Rubus hispidus,* and *Scutellaria lateriflora.* Some species found only here include *Bartonia virginica, Cryptotaenia canadensis, Osmunda claytoniana, Sorbus americana,* and *Thelypteris phegopteris. Sorbus americana* was most common as seedlings.

Cedar Swamp (T)

Although this stand may not be as floristically rich and extensive as most cedar swamps, this term best describes the 12 acre lowland conifer forest near Hamlin Lake. Moist conditions of this stand are maintained by a small stream passing through its center. *Thuja occidentalis* has the highest

cover (50%) and *Tsuga canadensis* (30%) is second. Trees with minor cover values include *Acer rubrum, Betula alleghaniensis, B. papyrifera,* and *Prunus serotina*. The dense shade of the interior of this stand and heavy deer yarding in the winter prevent an extensive development of a shrub layer, although *Vaccinium angustifolium* is present. Common herbs in this stand are *Botrychium virginianum, Athyrium filix-femina, Arisaema triphyllum, Clintonia borealis, Circaea alpina, Coptis trifolia, Dryopteris spinulosa, Galium triflorum, Gymnocarpium dryopteris, Mitchella repens, Mitella nuda, Osmunda cinnamomea, Thelypteris noveboracensis,* and *Trientalis borealis. Listera cordata* and *Cystopteris bulbifera* were found nowhere else in the study area.

This stand is not part of the proposed RARE II wilderness, but it was included within this study to illustrate the diversity of vegetation within the Nordhouse area. While it would not be afforded wilderness protection, the Forest Service ought to maintain this stand in its present condition.

Nordhouse Lake (L)

Nordhouse Lake covers about 13 acres in Sec. 35 NE ¼. The Nipissing ridge borders this lake on the west. If this ridge was formed on the fossil beach formed during the Calumet stage of Lake Chicago (Evenson et al. 1973), perhaps Nordhouse Lake was once a lagoon at the mouth of a stream which entered into that ancient glacial lake. The present lake rests on the underlying clay pan and is not more than 6 feet deep. In the spring it is filled by melting snow and rain. During the rest of the year the lake recedes through percolation and evaporation. The lake level is an accurate indicator of the soil moisture in the surrounding woods, and during some droughts this lake has even dried up.

The annual protracted lowering of Nordhouse Lake does not allow the typical pond emergents to develop. Instead, plants such as *Eleocharis acicularis, E. smallii, Spartina pectinata, Mollugo verticillata,* and *Rotala ramosior* inhabit the mud flats around the lake. *Potamogeton gramineus* is the only submerged aquatic. Species characteristic of the vegetation at the margin of this lake include *Agrostis hyemalis, Alisma plantago-aquatica, Anemone canadensis, Aster tradescanti, Cephalanthus occidentalis, Hypericum kalmianum, Iris virginica, Lobelia spicata, Lysimachia lanceolata, Mentha arvensis,* and *Spartina pectinata*.

Stachys hyssopifolia, at its northern-most limit in Michigan (Waterman 1960), can be found in the grass along the lake margin. Peattie (1922) listed this species as a Coastal Plain disjunct, and suggested that such disjuncts first occupied the coastal lagoons along Lake Michigan upon their arrival to this region. Today such disjuncts are generally confined to the edges of lakes and depressions similar to Nordhouse Lake.

The Meadow (G)

The meadow is located at the north end of Nipissing trail in Sec. 26. As is the case with Nordhouse Lake, the Nipissing ridge borders the meadow's

west side. Perhaps this area had also been a lagoon of an earlier lake, but its smaller size has allowed it to succeed to a meadow. In the spring, however, it may be filled with water up to 2 feet deep, which will usually disappear by early July. The flora of the meadow is similar to that around Nordhouse Lake. *Spartina pectinata* is a dominant species and *Eleocharis elliptica, Lysimachia lanceolata,* and *Lobelia spicata* also occur here. Along the outer edge *Cornus stolonifera* and *Hypericum kalmianum* are common shrubs. One species found only here is *Spiraea latifolia*. Other species occurring here, partly due to the drier conditions during the later parts of the growing season, include *Centaurea maculosa, Erigeron strigosus, Fragaria virginiana, Helianthemum canadense, Oenothera oaksiana, O. perennis, Potentilla simplex, Prunella vulgaris, Pteridium aquilinum,* and *Tragopogon dubius.*

Ponds, Marshes, and Alder Thickets (AT)

The alder thickets, marshes, and ponds are a collection of locally wet sites on the dune apron, which usually have standing water throughout the summer. The greatest concentration of these areas is in Sec. 26. Ponds are those sites with a large portion of their area remaining as open water. The marshes have less open water and instead are dominated by *Typha latifolia.* The alder thickets have little open space and in most places have a dense *Alnus rugosa* cover of 100 percent. *Ilex verticillata,* however, also occurs around these wetland areas.

Herbaceous species commonly occurring in and around the ponds, alder thickets, and marshes include *Arisaema triphyllum, Bidens frondosa, Boehmeria cylindrica, Caltha palustris, Carex crinita, C. folliculata, Dulichium arundinaceum, Iris virginica, Lycopus uniflorus, Lysimachia thyrsiflora, Onoclea sensibilis, Osmunda cinnamomea, Polygonum amphibium, P. hydropiperoides, Potentilla palustris, Rosa palustris, Scirpus cyperinus, Sium suave, Thelypteris palustris, Triadenum virginianum, Viola cuculata, V. macloskyi,* and *Woodwardia virginica.*

Perhaps this assortment of wet areas might be the remains of an early stream system which drained into Lake Nipissing or even Lake Calumet before this area was forested. Porter Creek, a present day stream which flowing into Lake Michigan north of the study area, has its origins in the alder thickets of Sec. 26.

Bogs (B)

The bogs of the study area do not have floating mats, but are shallow and overgrown with *Chamaedaphne calyculata.* A few small bogs occur in the oak woods, but the largest bogs of the study occupy parts of the marginal dune apron in Secs. 25 and 26. These bogs probably had their origin as dune pools and swales. Presently they occupy shallow depressions which collect water during the winter and spring. Their interior is covered with dense stands of *Chamaedaphne calyculata* and *Vaccinium angustifolium.* Lesser amounts of *Kalmia polifolia, Gaylussacia baccata,* and *Vaccinium myrtilloides* are also found in the open areas. An occasional *Larix laricina* and

Picea mariana are scattered across the bogs, but are more common close to the bog margin. The extreme outer edges are densly surrounded by *Nemopanthus mucronatus,* although *Aronia prunifolia* and *Viburnum cassinoides* are also found along the edges. Herbs in these areas include *Eriophorum virginicum, Scirpus atrovirens, S. cyperinus, Rubus hispidus,* and *Woodwardia virginica.*

The bog-swamps in Sec. 34 SW ¼ are an exception to this general description. These wetlands are an extension of Lost Lakes lying just south of the study area in Secs. 3 and 4 of Hamlin Twp. Here a zonation from open water to shrubs and trees is observed. *Nemopanthus mucronatus* and *Myrica gale* are common bordering the open water and along the edges near the surrounding upland forest. Conifers such as *Pinus strobus* and *Larix laricina* are common further from the open water. Graminoids including *Calamagrostis canadensis, Eriophorum virginicum,* and *Scirpus atrovirens* are common in this zone. *Acer rubrum* dominates the next zone where a small wet lowland forest has developed. Species found in this bog which were not found in the bogs of the dune apron are *Myrica gale, Calla palustris,* and *Iris virginica.*

The dune apron bogs do not have a high number of species, possibly due in part to the variability in water level during the year. These bogs can be very wet in the spring, and at times water may even cover FR 5356. By mid-July, however, the standing water disappears and *Sphagnum* begins to dry out in some places. Those species requiring moist conditions throughout the year cannot survive during the dry late summers, while those xeric species which may invade the bogs in late summer are eliminated in the wet springs. The moderating effect of the water of deeper bogs during the winter and the summer is also absent. The remaining bog flora of the Nordhouse region is limited to species with wide temperature and moisture tolerances.

Aerial photographs of this area from 1938 show that the dune apron bogs were much larger and occupied much of the area now covered by *Pinus resinosa.* This trend from bog to pine forest is likely to continue in the future.

Red Pine Forest (F)

A forest dominated by over 75 percent *Pinus resinosa* is closely associated with the bogs of the sand apron. In some places *P. resinosa* even has a cover of 100 percent although some *Quercus velutina* and *Populus grandidentata* inclusions are found on the drier ridges. *Acer rubrum, Betula papyrifera, Quercus alba,* and *Q. rubra* may also occur with an understory of *Gaylussacia baccata, Hamamelis virginiana, Vaccinium angustifolium, V. myrtilloides,* and *Viburnum cassinoides.* I have also used this forest type to map the red pine plantations which date back to the 1940s. These plantations are much drier and barely support any herbaceous species. Common herbs in the natural red pine forests include *Cornus canadensis, Cypripedium acaule, Dactylis glomerata, Epigaea repens, Galium triflorum, Gaultheria procumbens, Maianthemum canadensis, Pteridium aquilinum,* and *Trientalis borealis.* As succession continues these forests will replace the bogs of the sand apron.

Aspen Stands (A)

In some of these stands such as the area north of Nordhouse Lake, *Populus grandidentata* is widely spaced with an assortment of other tree species such as *Acer rubrum, Amelanchier laevis, Betula papyrifera, Pinus resinosa, P. strobus, Quercus alba,* and *Q. rubra*. Dense stands develop in some areas, such as those stands in Sec. 35 east of Nordhouse Lake, allowing few other tree species to become established. In the open stands *Pteridium aquilinum* is the dominant herb with 75–100 percent cover. This cover value is much smaller (@ 25%) in the closed aspen stands where *Populus grandidentata* has a cover over 75 percent. Grasses including *Poa compressa, Deschampsia flexuosa,* and *Danthonia spicata* occur here as do ericaceous species such as *Vaccinium angustifolium, Epigaea repens, Gaylussacia baccata,* and *Gaultheria procumbens*. These areas are successionally young and will be followed by either oak or mixed hardwood forests depending on the local conditions.

Open Disturbed Sites

Open disturbed sites are those areas which have recently experienced or are experiencing direct human influence. The three basic types of this influence are logging, powerline rights-of-way, and roads.

A 32 acre clearcut made in 1977 lies just north of the red pine plantation in Sec. 35. Before timber harvest this area had been classified as aspen by the Forest Service. *Populus grandidentata* saplings were very common in this clearcut at the time of these observations. Grasses such as *Agropyron repens, A. trachycaulum, Danthonia spicata, Phleum pratense,* and *Poa compressa* along with *Pteridium aquilinum, Fragaria virginiana,* and *Epigaea repens* constitute the herbaceous cover. *Comptonia peregrina* is common near the margin of this area.

Two powerline clearings cross the study area. The old right-of-way which crosses Secs. 27 and 34 once carried electricity to the lighthouse at Big Point Sable. In the early 1970s, this line was removed, but the clearing became a popular access route to the dunes for ORVs. A newer clearing, cutting across Secs. 36 and 25, was made to carry power to Lake Michigan Recreation Area. Both rights-of-way have exposed both wet and dry forest floors to sunlight. The undisturbed dry sites are usually predominatly covered by *Pteridium aquilinum,* while the wet sites are dominated *Osmunda cinnamomea, Scirpus atrovirens,* and by several species of *Carex*. One noteworthy site occurs where a part of the cedar swamp in Sec. 34 SE ¼ was cut. This opening has favored the growth of *Caltha palustris, Lobelia cardinalis,* and *Drosera rotundifolia*.

Roads delimit the boundaries of much of the study area. Local moisture conditions as well as the maintenance of FR 5356, FR 5629, and Nurnburg Rd have an effect on the species composition along the roads. FR 5356 is an unimproved two-track occasionally used by four-wheel drive vehicles in the summer and fall. The species along the edge of this road vary little from the

surrounding forests and bogs. Nurnburg Rd is a medium duty gravel road which is cleared of snow in the winter. Its shoulders, however, are not maintained, so tall growing species such as *Agropyron repens, Bromus inermis, Phleum pratense,* and *Hypericum perforatum* are common. FR 5629, a medium duty paved road, is closed in the winter, but its shoulders are mowed during the summer. Species such as *Barbarea vulgaris, Berteroa incana, Melilotus alba,* and *Hieracium aurantiacum* are common along this roadside.

CLIMAX VEGETATION

One possible climax in dune succession is a rich beech-sugar maple forest (Fuller, 1934) with herbs such as *Actaea pachypoda, Allium tricoccum, Dentaria diphylla, Dicentra canadensis, Dryopteris marginalis, Mitella diphylla, Sanguinaria canadensis, Trillium grandiflorum, Uvularia grandifolia,* and *Viola canadensis* similar to that found on some perched dunes in Sleeping Bear Dunes National Lakeshore. In the Nordhouse area, however, only a small upland site in Sec. 26 SE ¼ has a forest partially resembling this climax. *Acer rubrum,* not *A. saccharum,* characterizes both the mixed and lowland deciduous forests in the Nordhouse area. Climax vegetation, of course, is a function of local conditions. Perhaps the soils of this area, derived from lake-sorted sand rather than from wind-eroded morainal bluffs, are not rich enough to support an extensive sugar maple growth. Additionally, the regeneration of *Acer rubrum* may have been encouraged by the wet nature of the marginal dune apron after logging.

Another possible dune climax described by Olson (1958) is an oak forest typical of the dunes in Indiana. This forest is best represented in the Nordhouse area by the oak forest type now occupying most of the Nipissing and Algoma dunes. Olson suggests that rapid leaching of the sand is preventing the development of soils which would favor a beech-maple forest. In the Nordhouse area the oak forest appears to be succeeding to white pine. This trend would be more likely to continue at Nordhouse rather than along the southern end of Lake Michigan due to the importance of fire in maintaining the climax there (Harman 1970) and a greater boreal influence.

The model of sand dune succession and climax forests only describes a general pattern. The details of this pattern are a function of the local conditions of a given area. Although the Nordhouse Dunes study area does not exhibit a ''typical'' dune climax, succession from bare sand to forest has occurred here and vegetation changes may still occur in the future. Four distinct areas, the open sand, wooded dune ridges, and the upland and lowland sites of the marginal dune apron, characterize the study area. Open sand will continue to prevail due to shifting wind patterns, the wooded dune ridges will have a slightly different composition from the upland areas of the marginal sand apron, and the clay pan will continue to provide wet areas on which a forest distinct from the upland areas of the sand apron will develop.

CONCLUSIONS

This study, complete with its description of the various vegetation types and botanical inventory, not only provides an analysis of a little known stretch of dunes, but also enhances our knowledge of the Nordhouse area itself. The area's status as a proposed wilderness and the possibility of oil exploration there emphasize the need for an investigation beyond the previous timber surveys. This study, therefore, provides some baseline data by which future changes in this potential wilderness may be observed.

The biological significance of this area, in part, is measured by its diversity of habitats and the occurrence of threatened species. A wilderness here, buffered by National Forest land and Ludington State Park, would not only protect threatened species such as Pitcher's thistle (*Cirsium pitcheri*), but would also permit the preservation of an assortment of vegetation types. From such an area we can begin to understand its complexity and perhaps even measure the impact of human disturbance on other dune areas.

Over 90 percent of the study area is within the Grant-Hamlin-Pere Marquette Series I Area designated under the 1977 Michigan Sand Dune Protection and Management Act. Sand mining in Series I areas is closely monitored by the Michigan Department of Natural Resources. Sand mining is not a management alternative for the Nordhouse area, but this study provides background data to facilitate evaluating the degree of human disturbance in similar dune areas.

The Nordhouse Dunes provide outstanding recreational and educational opportunities. Hikers and cross-country skiers are attracted by the natural character and the intrinsic beauty of the Nordhouse area. Occasional hunting and camping also occur. Watson (1976) has suggested that the area could be used as an outdoor laboratory to demonstrate soil formation and illustrate postglacial lake history. Likewise, high school and college classes in geology, ecology, and botany could visit the area to observe the diversity of dune formations, habitats and plant species. Our knowledge and appreciation of the value of the Nordhouse area could be increased by studies on the birds, fungi, bryophytes, and other groups of organisms in the area as well as further botanical research.

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STUDIES ON MICHIGAN CHRYSOPHYCEAE. VI

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In previous papers by Wujek and co-workers (1972, 1973, 1975, 1977; Wee et al., 1982), the Chrysophycean flora of Michigan has been given. These reports were based on light, scanning, and transmission electron micrographs of 33 species and varieties, many of which were new to North America or new to science.

The present paper illustrates six species from southwest Michigan, four of them new to the contiguous United States (marked with an asterix below). The location for all of the taxa reported is Otis Lake, Barry County, the bog on its southern edge, and the stream draining it on the northeast side. Methods of collection and light and electron microscopy are as described in the papers cited above. Also included are corrections and updated nomenclature for the previously reported taxa.

**Mallomonopsis ouradion* (Harris & Bradley) Harris (Fig. 1)

This species was recently reported for North America from British Columbia (Donaldson & Stein 1984). Its only other localities are England (Harris 1966; Harris & Bradley 1958), Czechoslovakia (Kalina 1969) and Japan (Takahashi 1978). It was the third most common taxon in my samples. Peterfi and Momeu (1976) have suggested that the genus *Mallomonopsis* should be combined with *Mallomonas* and made a subgenus primarily on the basis of a second, long flagellum.

**Mallomonas corcontica* (Kalina) Peterfi & Momeu (Fig. 2)

A member of the *Tripartae* series, it has been previously reported from Canada (Nicholls 1982), Romania (Peterfi & Momeu 1976), U.S.S.R. (Balonov 1979) and Czechoslovakia (Kalina 1969). *Mallomonas corcontica* was encountered frequently in my samples, second only to *Mallomonas heterospina* Lund, a species first illustrated and reported as occurring in North America from Michigan (Wujek et al. 1975).

**Mallomonas hamata* Asmund (Fig. 3)

Only scales of this organism were observed, but they are distinctive so as not to be confused with any other member of the *Planae* series. Nicholls' (1982) report of this species from Canada found it to be common in the softwater lakes of Ontario. Kling and Kristiansen (1983), however, observed it from oligotrophic lakes, also in Canada.

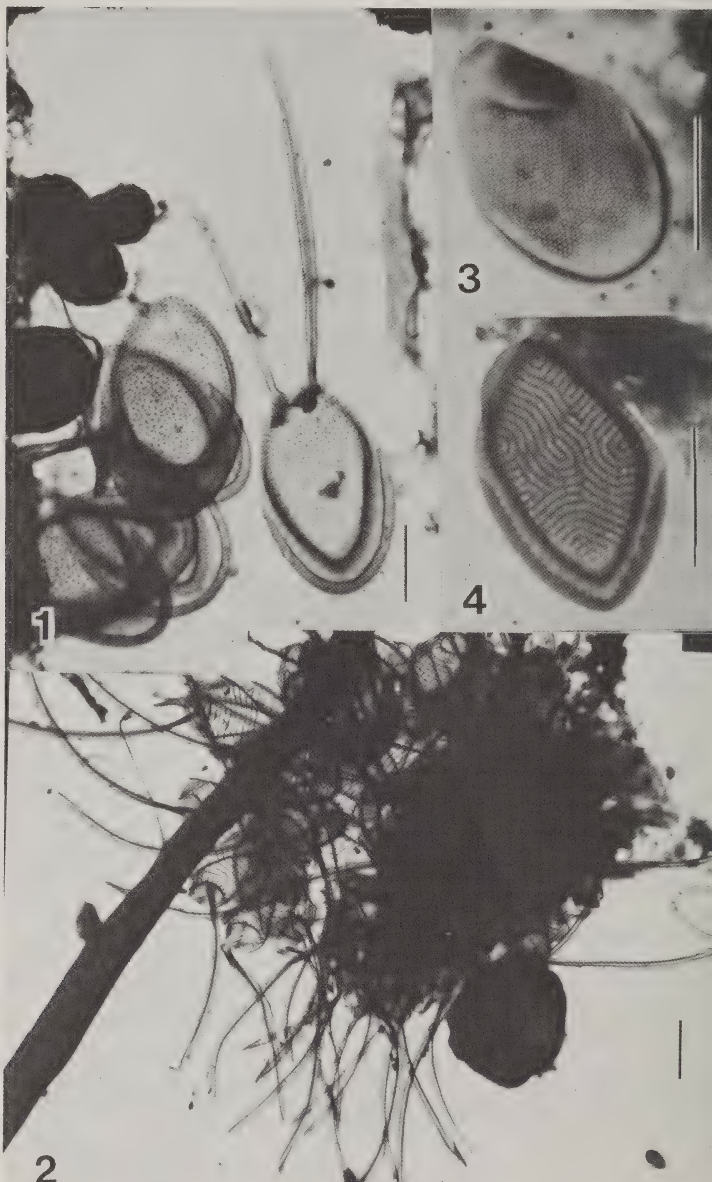

Fig. 1. *Mallomonopsis ouradion*. Group of scales and bristles. Fig. 2. *Mallomonas corcontica*. Whole cell with scales and bristles. Fig. 3. *M. hamata*. Single scale. Fig. 4. *M. schwemmlei*. Single scale. Bar = 10 μm.

**Mallomonas schwemmlei* Glenk (Fig. 4)

Scales of the species agree in size and structure described from its other known localities in Czechoslovakia (Glenk & Fott 1971), Federal Republic of Germany (Dürrschmidt 1984), Sweden (Asmund 1977; Cronberg & Kristiansen 1980), Holland (Roijackers 1981) and Canada (Nicholls 1982).

Mallomonas pillula Harris (Fig. 5)

The only previous reports of this species from North America are from Alaska (Asmund & Takahashi 1969), Minnesota (Wujek et al. 1981) and Canada (Nicholls 1982). The rhombodial scales with their short curved and tapered bristles are diagnostic features.

Synura spinosa Korsh. (Fig. 6)

This species as first reported for the state (Wujek & Hamilton 1972) is in fact *Synura curtispina* (Petersen & Hansen) Asmund. *Synura curtispina* is separated from *S. spinosa* chiefly by spines of the apical scales being shorter and less tapering, terminating in 3 or 4 minute teeth. The observation of *S. spinosa* scales in the Otis Lake samples reestablishes its presence in Michigan. Worldwide distribution for this species was recently noted by Donaldson & Stein (1984).

Since the publication of the first and subsequent numbers in this series, a few corrections and a number of nomenclatural changes, all of which I am in agreement with, are in order. The following taxonomic annotations are grouped by genera.

Mallomonas acaroides var. *crassisquama* Asmund first reported from Michigan in 1973 (Wujek & Hamilton 1973) is now referred to as *M. crassisquama* (Asmund) Fott. In this same paper, *M. oviformis* was reported as occurring in the state. In fact, the scales belong to the taxon *M. caudata,* previously reported for the state (Wujek & Hamilton 1972). In a recent revision of the *M. pumilio* group, Asmund et al. (1982) have indicated that *M. allantoides* (Wujek & Hamilton 1975) should be included under their newly described species *M. alata* f. *alata* Asmund, Cronberg & Dürrschmidt. *Mallomonas alpina* Pascher & Ruttner, synonymous with *M. monograptus* Harris & Bradley as it was first reported for the state (Wujek & Hamilton 1972), was also present in the Otis Lake samples. The taxon *M. pugio* Bradley reported earlier (Wee et al. 1982) has been reassessed and separated into two taxa, with our taxon now being referred to as *M. hindonii* Nicholls. The main features distinguishing *M. hindonii* from *M. pugio* are the shape, size and ornamentation of the scale. *Mallomonas hindonii*'s previous locations include its type locality Ontario, Canada (Nicholls 1982), and lakes from the Adirondack region of New York (Smol et al. 1984a, 1984b).

Synura spinosa f. *mollispina,* first observed in 1977 (Wujek et al. 1977) has since been raised to the rank of species [*S. mollispina* (Petersen & Hansen) Peterfi & Momeu].

In recent papers, Nicholls (1980, 1984) has offered solutions to problems that have existed between species belonging to the genus *Chrysosphaerella* and its three colonial and two unicellular taxa and the solitary

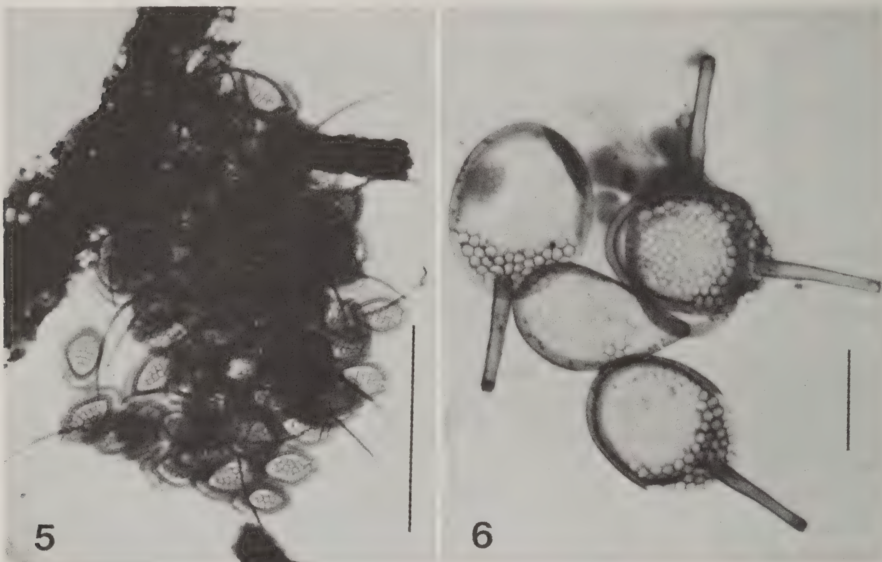

Fig. 5. *Mallomonas pillula*. Body scales and bristles. Fig. 6. *Synura spinosa*. Group of scales. Bar = 10 μm.

celled genus *Spiniferomonas*. As a consequence, the taxon *C. coronacircumspina*, first described from Lake Geneserath on Beaver Island (Wujek et al. 1977) and since observed worldwide, is now referred to as *S. coronacircumspina* (Wujek & Kristiansen) Nicholls based on this taxon's solitary growth habit and scale and bristle morphology.

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Erratum

In the paper, "A study of Red Cedar Natural Area. I.", the illustrations for Figures 1 (p. 29) and 2 (p. 31) were reversed.

PUBLICATIONS OF INTEREST

BOTANY ILLUSTRATED Introduction to Plants [;] Major Groups [;] Flowering Plant Families. By Janice Glimn-Lacy & Peter B. Kaufman. Van Nostrand Reinhold, New York. 1984. 146 pp. [+ illustr.]. $19.95. This paperback is a rather eclectic "discovery book" unlike anything else—and hence probably more useful than anything else to many amateurs, high-school and non-major college students, and anyone else who would like to learn something about plants. It features full pages (for some reason unnumbered) of excellent, ample drawings, with facing concise text on major plant groups, processes, anatomy, structure, pollination, and other topics. A color code on each numbered page indicates how colored pencils may be used to bring life to this sophisticated "coloring book." Up-to-date but very brief notes on such subjects as physiology and plant constituents are valuable for those who have been ignoring these matters. The notes on economic plants should be interesting to all. The paragraph on the wheat grain is a gem of information on nutrients in the various parts. The text is for the most part clear, although occasionally misleading. The pappus of the Compositae is much confused, the scales (as accurately drawn) of *Tagetes* described as "bristles," and the scale-like receptacular chaff of *Rudbeckia* (which has at best a little crown of a pappus) labeled as pappus "bristles." A pappus does not have to be hairy (p. 38), nor grass ligule membranous (p. 123, where both the family name Gramineae and the generic name *Zoysia* are misspelled). The "aggregate of achenes" in *Ranunculus* does not conform to the definition of aggregate fruit on p. 39. It is misleading to cite Amentiferae as if it were an alternative name for Salicaceae and not to mention that old name under any other of the amentiferous families. "Cow-parsley" would be a very unlikely common name for *Heracleum*, which is usually called cow-parsnip. Anyone can offer suggestions as to things they wish had been done, but if authors did everything their friends—and enemies—suggested, books would become too ponderous. One or two species (usually) serve to illustrate each family and sometimes could have been used to illustrate additional interesting points (e.g., while the 4-pronged hairs of *Salvinia* are noted, nothing is said of the beautiful 2-pronged hair of *Lobularia*). The native homes of the species depicted are not provided, so that one may, e.g., jump to the conclusion that if he has a prickly-pear it must be *Opuntia decumbens* (a species native nowhere in the U.S.). The bibliography often omits any indication of which edition of a work is cited and/or cites a later reprint and date rather than the original. But enough of trivia! This is an excellent and unique introduction to botany, which it is hoped will find a widespread market.

THE VASCULAR PLANTS OF INDIANA: A COMPUTER BASED CHECKLIST. By Theodore J. Crovello, Clifton A. Keller, & John T. Kartesz. American Midland Naturalist & Unviersity of Notre Dame Press, Notre Dame, Indiana. 1983. xxiv + 136 pp. $15.00. Families are listed in alphabetical order, the species (also alphabetical) keyed to page numbers in the Kartesz and Kartesz checklist and to map numbers in Deam's *Flora of Indiana*. Sources of additions to Deam are indicated by a number code; and of course subtractions and corrections have been accommodated. The preparation is fully explained in a helpful introduction, which even offers a "prose equation" for the whole laborious procedure, including numbers of "nomenclatural births" and "nomenclatural deaths" (quite unnecessary, since, unlike natural populations, such vital statistics can only equal each other if they are truly nomenclatural). For nomenclature, the authors relied "completely" on Kartesz and Kartesz—even to the point, obviously, of not correcting errors including those pointed out in earlier reviews of that list (e.g., in Syst. bot. 6: 92. 1981). So we find "Triandenum" for *Triadenum; Triglochin* treated simultaneously as feminine and neuter; erroneous author citations for *Polygonum amphibium* var. *stipulaceum*, two *Lathyrus* names, and others. *Carex leptalea* spp. *harperi* has the wrong author and is parallel to "var." *leptalea*—an odd discrepancy. It is not clear why, if mere correction of author citation merited inclusion of names in the long appendix itemizing changes from Deam, equally erroneous author citations in Kartesz and Kartesz should not have been corrected. Nevertheless, this

should be a helpful updated list for those who need the bare names and authors (no data on distribution or bibliographic references). Whether it needs the hardcover binding and consequent higher price may be debatable.

A FIELD MANUAL OF THE FERNS & FERN-ALLIES OF THE UNITED STATES AND CANADA. By David B. Lellinger. Smithsonian Institution Press, Washington, 1985. 389 pp. + 406 col. figs. $29.95 (paper); $45.00 (cloth). Definitions of pteridophyte species (and consequently their nomenclature) have been rapidly changing and undergoing refinement for a number of years. Here is the guide to bring you up to date as painlessly as possible. The type is large and readable. There are 406 color photos (90% of them by A. Murray Evans), most of them of living plants (some looking better when turned 90° for correct orientation). There are keys (parallel style, not indented), descriptions, ecological notes, comments on cultivation, and other information. Distributions are stated broadly (no maps) and fail to allow for *Lygodium palmatum* in Michigan or *Cryptogramma acrostichoides* in Minnesota. There is a thorough introduction, a concluding chapter on hybrid complexes, and illustrated glossary, and an extensive bibliography. (From the glossary one can learn that "epipetric" means "growing on rocks," confirming that habitat phrases like "epipetric on dry rocks and cliffs" are thoroughly redundant.) The author and principal photographer both did their graduate work with W. H. Wagner at The University of Michigan, and all parties concerned with this fine modern synthesis have ample reason to take pride in the accomplishment.

—E. G. Voss

The January issue (Vol. 25, no. 1) was mailed February 15, 1986.

CONTENTS

On the cover: Grass panicle covered by ice after ice storm. Photo taken southwest of Lansing, Ingham County, Michigan, in January, 1985 by Larry Lemanski.

Vol. 25, No. 3

THE MICHIGAN BOTANIST

May, 1986

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Articles dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the co-editors. In preparing manuscripts, authors are requested to follow our style and the suggestions in "Information for Authors" (Vol. 15, p. 238).

Editorial Board

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims; conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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245

GERMINATION OF SEEDS OF EPIFAGUS VIRGINIANA (OROBANCHACEAE)

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Epifagus virginiana (L.) Bart., commonly known as beechdrops, is a member of the parasitic Orobanchaceae. The life histories of numerous members of this family are well studied, but little is known concerning the establishment of *E. virginiana* on its host, *Fagus grandifolia* Ehrh., the American beech (see Musselman 1982 for a review of *Epifagus* life history). In fact, *Epifagus* seeds had never been germinated in the laboratory, although previous attempts were made. Standard methods used to promote seed germination in parasitic plants, such as direct seed contact with live host roots (Cooke & Schively 1904; Schlater 1979), chemical germination promotors (such as gibberellin; Musser 1979), and host root exudates (Musselman & Mann 1978; Muser 1979), failed to induce *Epifagus* seed germination in earlier studies. Our attempts to utilize live *Fagus* roots and *Fagus* root diffusates as germination promotors were also unsuccessful. However, in preliminary experiments with forest soils, we found that *Epifagus* seeds would germinate on soils from beneath *Epifagus* plants. The following experiment was designed to investigate the effect of soil on *Epifagus* seed germination.

MATERIALS AND METHODS

Epifagus seeds were collected from the Zuck Arboretum of Drew University, Morris County, New Jersey, during early October 1980 and stored in stoppered test tubes at 4°C. Forest soils from four sites were collected in March 1981. These included: 1) soil occurring beneath the *Epifagus* population that supplied the seeds for this study (arboretum soil); 2) soil surrounding an *Epifagus* population (>500 meters from seed-source population) in the Drew Forest Preserve (forest-preserve soil); 3) soil at the base of a beech tree that supported no *Epifagus* (non-*Epifagus* soil); and 4) soil that had no previous contact with *Epifagus* or beech (non-beech soil). All soil samples were collected from the lower portion of the organic horizon of the soil (02 horizon; Brady 1974), where partial breakdown of leaf litter and other organic matter formed a layer of humus. A small spatula was used to collect soil samples to a depth of 1 cm. Soil samples were sealed in separate, sterile glass jars and stored at 4°C until needed. Sixteen replicates of each soil were prepared on 17 March by placing the soils in 9 cm plastic petri plates to a depth of 8–10 mm. All soils were shaken manually for several minutes beforehand to insure uniformity within treatments. Petri plates containing arboretum and forest-preserve soils were searched with a stereomicroscope for any *Epifagus* seeds, which were removed upon discovery. Eight replicates of each soil were autoclaved before exposure to *Epifagus* seeds to determine whether germination promotors, if present in the soil, could be affected by high temperature. *Epifagus* seeds were removed for experimentation after approx-

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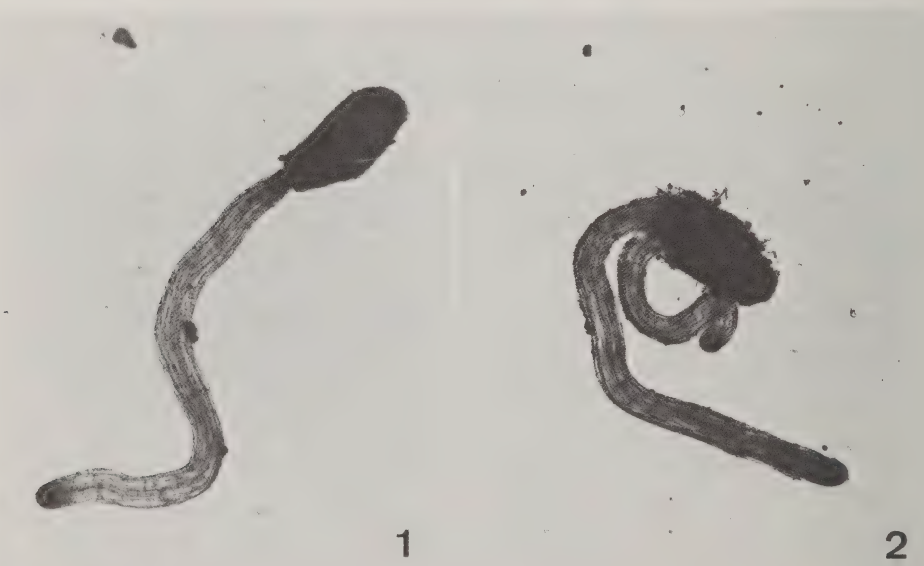
imately 150 days of cold storage. A 45% seed viability was determined by treating a random sample (n = 100) with a 1% weight/volume solution of the vital dye 2,3,5-triphenyltetrazolium chloride (Grabe 1961). Fifty *Epifagus* seeds were placed in each petri plate on 18 March. For all soils, four replicates of both autoclaved and unheated treatments were placed in a Precision Scientific Model 818 temperature cabinet and exposed to 12 hr light/12 hr dark photoperiods. Another four replicates of each were placed in a dark Elconap Model 1 incubator. Temperature during the study was kept at 26–27°C and soil surfaces were frequently misted with de-ionized, sterilized water to prevent desiccation.

RESULTS AND DISCUSSION

Germination occurred almost exclusively on the non-autoclaved arboretum soil exposed to the photoperiod (Table 1). Germination was first observed 20 March and subsided by 27 March after 29% (57) of the *Epifagus* seeds had germinated. Seedlings measured approximately 1 mm in length and were composed predominantly of primary root (Figures 1 and 2). No germination was observed on any of the other soils subjected to the photoperiod. Soils kept under darkness produced no germination, except for the non-autoclaved arboretum soil, in which 2.5% (5) of the seeds germinated. This low germination may be the result of light received when soil replicates were checked for germinated seeds.

These results indicate that soils surrounding *Epifagus* populations contain a germination promotor that is thermolabile and potentially population specific. The heat-sensitive nature of this promotor suggests a compound of host origin, a microorganism (such as a mycorrhizal fungus), or a combina-



Figures 1–2. Germinated seeds of *Epifagus virginiana*. 1. Seedling of *Epifagus virginiana* (actual size 1 mm in length). 2. Polyembryonic seedling of *Epifagus virginiana* (actual size 0.8 mm in length).

TABLE 1. *Epifagus* seed germination on various soils. Each soil treatment consisted of 200 seeds.

Soil type	Autoclaved 12:12	Autoclaved dark	Non-autoclaved 12:12	Non-autoclaved dark
arboretum	0	0	57	5
forest-preserve	0	0	0	0
non-*Epifagus*	0	0	0	0
non-beech	0	0	0	0

tion of these and possibly other factors. While host-derived compounds are important germination promotors in the Orobanchaceae, there is little evidence for mycorrhizal associates in this family (Kuijt 1969). However, the lack of evidence for mycorrhizae may be based primarily on observations of adult plants, which obtain the majority of their nutritional complement from the host. Seedlings, on the other hand, are limited by nutrient stores and may require a mycorrhizal fungus for successful host establishment, analogous to germination and early establishment in *Cypripedium* and other orchids (Jackson & Mason 1984). The presence of an endophytic fungus has been noted in seedlings of an *Orobanche* species (Cezard 1974) and it is possible there are more such occurrences in the Orobanchaceae. The need for a mycorrhizal fungus in conjunction with a host-derived compound could explain the difficulties associated with seed germination of *Epifagus* and *Conopholis* (squawroot) in the laboratory.

The lack of seed germination on forest-preserve and non-*Epifagus* soils may be related to the breeding system of *Epifagus*. At maturity, *Epifagus* bears both chasmogamous and cleistogamous flowers; cleistogamous flowers produce the majority of seed whereas chasmogamous flowers are sterile (Cooke & Schively 1904) or produce negligible amounts (Schlater 1979). Thus, self-fertilization predominates in *Epifagus* reproduction, exceptional for the primarily outcrossing Orobanchaceae (Kuijt 1969). Emphasis on autogamous reproduction may increase population homozygosity and result in the formation of differentiated demes (local populations of related, interbreeding organisms in which interpopulation gene flow is restricted; Pianka 1983) on individual trees, each deme adapted to the unique physiology of the host. This phenomenon is well known in the scale insects, which utilize a similar reproductive strategy (Edmunds & Alstad 1978; Wainhouse & Howell 1983). Beech reproduction by root sprouting may favor *Epifagus* demic differentiation through perpetuation of the host genotype, although the significance of root sprouting varies between regions (Held 1983). Demic differentiation in *Epifagus* may explain the patchy distribution of parasitized beech trees in forests. Wainhouse & Howell (1983) reached a similar conclusion in explaining the discontinuous distribution of the scale insect, *Cryptococcus fagisuga*, on *Fagus sylvatica* in Britain.

The host-parasite relationship of *Epifagus* and beech appears to be complex, hence the previous lack of success in laboratory germination of *Epifagus* seeds. While the amount of germination observed in this study was

low, we feel a significant step has been made toward understanding this intriguing relationship. The presence of a thermolabile, soil-borne germination promotor in *Epifagus* has now been demonstrated, although its nature has yet to be determined. Our results suggest that photoperiod also plays a role in germination. Autogamy may further complicate studies of this relationship through the production of differentiated demes of *Epifagus*, each possibly requiring a unique host-derived germination promotor. Further studies should address both the germination ecology and breeding system of *Epifagus* to provide knowledge useful to understanding the host-parasite relationship of *Fagus grandifolia* and *Epifagus virginiana*.

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THIRTEENTH ANNUAL NATURAL AREAS CONFERENCE

The rolling St. Francois Mountains in southeast Missouri will be the setting for the Thirteenth Annual Natural Areas Conference Oct, 21–24, 1986. The conference will be held at the new Trout Lodge Conference Center, a part of the YMCA of the Ozarks near Potosoi, Mo. The sponsors of the 1986 conference are the Natural Areas Association, the Missouri Natural Areas Committee, the Missouri Department of Natural Resources, the Missouri Department of Conservation, and the Missouri Chapter of The Nature Conservancy. Details on registration information are available from the Natural Areas Conference, P.O. Box 180, Jefferson City, MO 65102.

VIOLA × BRAUNIAE (VIOLA ROSTRATA × V. STRIATA)

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On November 3, 1918, E. Lucy Braun, of Cincinnati, sent two violet collections, one made in 1917 and the other from the same site in 1918, to Ezra Brainerd of Middlebury, Vermont, with the following letter:

"After a long delay, I am sending to you specimens of the hybrid violet, *V. striata* × *rostrata*. I visited the locality a little too late this year and found only a few plants still in bloom. These were all hyrbids—none of the *V. rostrata* parent. I did not examine the plants as carefully as I should have when I first found the patch [in 1917]—my reason for not doing so was the arrival of a violent thunderstorm. Of those that I picked, I had only one specimen of *V. rostrata* among several of the hybrid. Although the plants looked strange, I took all the specimens to be *V. rostrata* while gathering them, for I was not at all familiar with this species having only seen it growing once before, in Kentucky. It had never been recorded from the vicinity of Cincinnati before. *V. conspersa* has never been found here. The specimens of *V. striata* were gathered some distance from the larger patch of hybrids, probably several hundred yards away. *One* hybrid specimen *only* was found in this spot.

"I will be glad to send you at any time for examination, my herbarium specimens of the hybrid and of the *V. rostrata* which I collected at the same time. Make any use of these that you may wish, I do not wish to publish anything concerning them. The occurrence of *V. rostrata* will of course be noted in our county lists.

"I have a plant of the hybrid growing in my garden. For two summers it has produced cleistogamous flowers abundantly, but has failed to develop any seed. Thus far this plant has proved to be entirely sterile."

A few years later in his publication on naturally occurring violet hybrids, Brainerd (1924) included an account of "*Viola rostrata* × *striata* Brainerd hyb. nov." based on the letter and specimens from Braun. He wrote this diagnosis: "Outline of leaf-blade broadly ovate-cordate, acuminate; stipules slightly fimbriate as in *V. rostrata;* like *V. striata* in its thick, short, blunt, spur and bearded lateral petals." He included also a drawing by F. Schuyler Mathews of the three individual plants comprising Braun's 1917 collection. These were later mounted on a single sheet, and the three 1918 specimens mounted on a second sheet.

Later still, Grover (1939) proposed the name "× *Viola braunii* nom. nov." for this hybrid and repeated, in English, Brainerd's diagnosis. As Voss (1985, p. 596) recently noted, this did not constitute valid publication. The name is published here with a Latin version of Brainerd's diagnosis, slightly altered, and designation of a holotype.

Hybrid No. 77—**Viola rostrata × striata**

Fig. 1. *Viola × brauniae* (From Brainerd, 1924).

Viola × brauniae Grover ex Cooperrider hyb. nov.

Hybrida; foliis late ovato-cordatis; stipulis leviter fimbriatis similis *V. rostratae;* calcare crasso et obtuso, et lateralibus petalis barbatis similis *V. striatae*. Holotype: OHIO. Hamilton County, nr. Terrace Park, north slope, mesophytic woods. *E. L. Braun s.n.*, 27 May 1917 (VT).

Paratype: OHIO. Hamilton County, near Terrace Park, north slope, mesophytic woods. *E. L. Braun s.n.*, 26 May 1918 (VT).

Lynne D. Miller, a recent student of Ohio violets, found this to be the most common violet hybrid in Ohio, with collections from 35 of the state's 88 counties (Miller, 1976). Dr. Braun was a devoted student of the Ohio flora (Cooperrider, 1984; Stuckey, 1973). It is doubly appropriate for this frequent Ohio hybrid to be named in her honor.

I thank David S. Barrington and Margaret L. Shultz of VT for the loan of the Braun letter and specimens, John H. Parks for assistance with the Latin diagnosis, and Edward G. Voss for a critical and helpful review of the manuscript. I acknowledge with thanks support from the Ohio Department of Natural Resources that made this work possible.

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THE DISCOVERY OF DRABA GLABELLA IN MICHIGAN WITH NOTES ON DRABA FROM ISLE ROYALE NATIONAL PARK

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The genus *Draba* (Cruciferae) consists of approximately 300 species of mainly arctic and alpine herbs found in temperate and boreal regions of the Northern Hemisphere, as well as in the mountains of Central and South America (Willis, 1966). Five species have previously been reported from

Michigan (Voss, 1985). Two of these, *D. arabisans* Michx. and *D. incana* L., have been collected in Isle Royale National Park.

In late June–early July, 1985, we had the opportunity to visit Passage Island in Isle Royale National Park in order to undertake a floristic survey of rare plants for the Michigan Natural Features Inventory. Isle Royale National Park is located in western Lake Superior, ca. 89 km northwest of the Keweenaw Peninsula, and consists of a large central island and numerous smaller islands. Passage Island is at the northeastern end of the park (T67N, R32W; 48° 14′N, 88° 21′W), about 5.5 km northeast of the main island, and is ca. 1.0 square km in area. The park has a large number of boreal species (Slavick & Janke, 1984), and Passage Island is particularly rich in this element of the flora. Many of these plants occur on the exposed rock shores and inland cliffs which are frequent on the islands. Several botanists have collected in the park and a great deal is known about the flora of the main island, though little intensive botanical exploration has been undertaken on Passage Island.

Draba arabisans is known from several localities in the park (Slavick & Janke, 1984), and was found to be common on Passage Island in areas of exposed rock along shores and in grassy-rocky clearings in the island's interior. Among the plants seen on the southwestern portion of the island, east of the lighthouse, were several aberrant clumps with highly thickened stems which appeared almost woody. The cause of this anomaly has not been determined; fungal infection or insect damage are likely possibilities.

While exploring the southwestern end of Passage Island on June 29, 1985, we found one colony of several white-flowered drabas that were different from the frequent *D. arabisans*. The leaf-rosettes were smaller and had much less pubescence on the upper leaf surfaces. A collection of these plants was later identified by Gerald A. Mulligan as *D. glabella* Pursh, albeit a somewhat less pubescent form than is typical. Although much of Passage Island was explored during this survey, only ca. 20 plants were found, 100–150 m northeast of the lighthouse, in rock crevices and at the edge of *Abies balsamea–Sorbus decora* forest. Associates included *Cornus canadensis*, *Lycopodium obscurum*, and *Maianthemum canadense*. Further exploration of the high cliffs on the north side of Passage Island, as well as other islands in the park, may reveal additional populations of *D. glabella*, some of which may have been previously overlooked due to their similarity to *D. arabisans*.

This is the first report of *Draba glabella* (*sensu stricto*) from the Lake Superior area (Mulligan, pers. comm.). The species is known from only two other areas in the Great Lakes region—Manitoulin Island, and a site near the Ontario-Quebec border north of Lake Ontario (Mulligan, 1970). Morton and Venn (1984) did not consider *D. arabisans* distinct from *D. glabella* on the basis of Manitoulin Island populations. Hence, they mapped them together under the name *D. glabella*. Mulligan (1970, 1976) recognized the species as distinct on the basis of differing chromosome numbers and morphological differences.

A third species of *Draba, D. incana,* has been collected on Passage Island and Gull Islands (6 km northeast of Passage Island) in the park (Given & Soper, 1981). While exploring the northern end of Passage Island in late July, 1985, Janet Marr and Sue Crispin were able to locate only two plants of *D. incana*. One of the plants was found on a rock outcrop 2 m above Lake Superior and the other in duff under balsam fir. Subsequent searching of the small, rocky, unforested islands ca. 200 m east of the northern end of Passage Island revealed over 300 additional *D. incana* on protected ledges and crevices of steep northwest-facing cliffs. Vascular vegetation was sparse, probably due to extensive gull activity, guano accumulation, and nearness to lake level. Associates included *Achillea millefolium, Campanula rotundifolia,* and *Calamagrostis canadensis.*

Voucher specimens were prepared for each species and have been deposited as follows: *Draba arabisans*—Freudenstein 1683, MSC; 1706, MICH; *D. glabella*—Freudenstein 1682, MICH, MSC; *D. incana*—Crispin 1043, MSC; 1050, MSC.

ACKNOWLEDGMENTS

We wish to thank the Michigan Natural Features Inventory for making the trips possible, and the National Park Service for permission to stay on Passage Island and for their continued assistance during our stay at the park. We also thank Gerald A. Mulligan for identification of *D. glabella,* Susan R. Crispin for additional habitat information, and Edward G. Voss and Janice M. Glime for comments on the manuscript.

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CHAMPION TREES OF MICHIGAN

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This revised list of Michigan Big Trees includes 16 new National Champions for the state, in addition to 17 new State Champion trees. These additions illustrate the constant change occurring in this field. Several huge National Champion trees were lost as a result of severe windstorms since the publication of the last list (Thompson 1983). These losses include a very large 283-in (girth) red oak located north of St. Joseph, the giant 284-in tuliptree near Russ Forest, the 235-in Jack oak (hybrid), near Durand, and a 254-in black oak at Lambertsville. The 245-in white ash near Adrian died, the 101-in red pine in the Porcupine Mountains was uprooted by stream erosion, and the 142-in pear in Clawson was destroyed by construction. In addition, several of our other National Champions were replaced by larger specimens. Furthermore, five Michigan National Champions were eliminated by the decision of the American Forestry Association to no longer list hybrids.

However, these losses were compensated by the discovery of new National Champions: a 222-in red maple, 193-in thornless honeylocust, 216-in boxelder, 323-in black willow, and a 251-in white mulberry. The Huron Mountains supplied two champion white pines (202 & 186 in) and a 105-in largetooth aspen. Other champion species were apple, speckled alder, red pine, black ash, downy shadbush, and pear. As a result of these additions Michigan now claims 82 National Champions, second only to Florida.

Among the new State Champions are: 268-in red oak, 218-in white ash, 213-in American elm, 205-in sugar maple, and a 109-in chestnut oak. Also, in this group are a 180-in copper beech, 157-in white birch, 134-in Ohio buckeye, and 118-in apricot.

The tabulation includes many huge trees. Forty-three have girths that reach 180 in (15 ft), with 17 surpassing 240 in (20 ft). Trees with girths exceeding 300 in are white willow, cottonwood, brittle willow, and black willow with the greatest of 337 in. The tallest tree is a white pine with a height of 202 ft. Seven trees possess heights exceeding 150 ft.

To obtain tree measurements, girth (circumference) is measured with a steel tape at a trunk height 4½ ft above normal ground level. If the trunk splits below 4½ ft, then only the largest segment is measured. Crown spread is obtained by projecting the outline of the crown onto the ground and then determining the average diameter of the outline. The height is best checked with an Abney handlevel or clinometer.

State Champions are based only on girth. Previous lists of these champions can be found in the Michigan Botanist (Thompson 1975) and in the Michigan Natural Resources Magazine (Thompson 1983, and McKee

1979). On the other hand, National Champions are based on a point system. Total points are calculated by adding girth in inches to the height in feet, plus one fourth of the spread in feet. The American Forestry Association (1319 Eighteenth St., N.W., Washington, D.C. 20036) then declares the specimen with the largest score the champion. If two trees score within five points of one another, and if the girths and heights are different, then both trees may be declared champions. Lists of National Champions are presented in *American Forests* (Hartman 1982) and a supplement (Hunt 1984). The following tree list is similar to the one used by *American Forests*. The nomenclature used is Voss (1972, 1985); for names not found in Voss, I used those of Barnes & Wagner (1981); and for a few not covered in any of these publications, those of Gleason (1952).

Information on trees should be sent to the Big Tree Secretary: Helen Durham, 33725 Oakland, Farmington, MI 48024. Include tree name, location, girth in inches (height and crown spread, if possible), your name and address.

CHAMPION TREES OF MICHIGAN

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
+Ailanthus, Tree-of-heaven *Ailanthus altissima*	135 (43)	108	91	St. Clair: Marine City, 1020 S. Belle River Rd	HN
+Alder, European or black *Alnus glutinosa*	84 (27)	66	45	Wayne: Trenton, Elizabeth Park	HN
Alder, mountain or green *A. crispa*	*10 (3.2)	28	12	Marquette: Huron Mountain Club (Big Bay)	PT
Alder, speckled *A. rugosa*	*38 (12)	66	56	St. Clair: Avoca, 4238 Bricker Rd	W. Brennen, PT & R. Kilroy
+Apple *Malus pumila*	*133 (42)	43	59	Oakland: Bloomfield Hills, Quarton & Forest Rds	J. Kaplan & PT
+Apple, prairie crab *Malus ioënsis*	*36 (11)	41	44	Oakland: Beverly Hills, Kirkshire Rd & Birmingham Blvd	PT
Apple, wild or sweet crab *M. coronaria*	26 (8.3)	28	33	Wayne: Plymouth, Haggarty & Middle Rouge Rds	HN
+Apricot *Prunus armeniaca*	118 (38)	54	63	Leelanau: 3 mi N of Suttons Bay, Solem & Stave Rds	A. Bakker & PT
Ash, black *Fraxinus nigra*	*99 (32)	155	108	Lenawee: Adrian, N of Island Park	R. Smith & PT
Ash, blue *F. quadrangulata*	68 (22)	--	--	Washtenaw: SW of Plymouth, 5683 Napier Rd	H. Conant
Ash, red *F. pennsylvanica*	*242 (77)	131	121	Cass: 4 mi NW of Dowagiac, Topash & Townline Rds	R. Meisterlein & PT
Ash, white *F. americana*	218 (69)	91	100	Antrim: 2 mi SE of Elk Rapids	N. Ver Hag & PT

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
Aspen, largetooth Populus grandidentata	*105 (33)	132	67	Marquette: Huron Mountain Club, Fisher Creek Trail	PT
Aspen, quaking P. tremuloides	*122 (39)	109	80	Ontonagon: Porcupine Mountain State Park, South Boundary Rd	HN
+Bald-cypress Taxodium distichum	113 (36)	79	66	Ionia: Saranac, 128 W Division St	PT
Basswood Tilia americana	*275 (88)	101	67	Grand Traverse: Old Mission Peninsula Schoolhouse	A. Hodge
	251 (80)	78	99	Ingham: W of Plainfield, 5456 M-56 & Kinsey Rd	HN
Beech, American Fagus grandifolia	172 (55)	74	109	Manistee: N of Portage Lake	H. Harvey & O. Schenima
+Beech, copper F. sylvatica 'atropunicea'	180 (57)	95	83	Barry: Gull Lake, Kellogg Biological Station	S. Bassett
+Birch, European white B. pendula	151 (48)	109	92	Leelanau: Greilickville, 11810 Cherry Bend Rd	PT
Birch, mountain paper** Betula cordifolia[3]	*108 (34)	90	88	Leelanau: W of Glen Lake, Sleeping Bear Dunes	PT
+Birch, river B. nigra	77 (25)	--	--	Kalamazoo: Kalamazoo, 3743 Gull Rd	J. Guzinski
Birch, white or paper B. papyrifera	157 (50)	128	116	Marquette: Huron Mountain Club, Fisher Creek Trail	PT
Birch, yellow B. alleghaniensis	178 (57)	114	101	Mackinac: 7 mi S of Gould City	W. Mahalak
Black-haw Viburnum prunifolium	17 (5.4)	24	17	Oakland: S edge of Lakeville, Swamp	PT
Bladdernut Staphylea trifolia	*19 (6.0)	36	37	Macomb: NW of Utica, Utica Recreation Area	HN & PT
Blue-beech, or hornbeam Carpinus caroliniana	40 (13)	40	52	Oakland: Ferndale, 1350 Jean St	PT
Boxelder, or Manitoba Maple Acer negundo	*207 (66)	110	120	Washtenaw: NW edge of Milan, Saline & Mooreville Rds	HN & PT
	*216 (69)	98	115	Livingston: Cohoctah, 1782 Gannon Rd	M. Limbers & PT
Buckeye, Ohio Aesculus glabra	134 (43)	104	58	Lenawee: Adrian, Raisin River, N of Maple Rd	R. Smith & PT
+Buckeye, red A. pavia	*91 (29)	64	52	Kalamazoo: Vicksburg, Prudential Nursery	C. Walters
+Buckthorn, common Rhamnus cathartica	*45 (14)	61	65	Washtenaw: Ann Arbor, N of Nichols Arboretum	D. Jones & PT
+Buckthorn, glossy R. frangula	*13 (4.1)	34	19	Oakland: Bloomfield Hills, Cranbrook	PT
Burningbush, eastern (see spindle tree)					
Butternut Juglans cinerea	179 (57)	96	130	Sanilac: Lexington, 7225 Simions St	HN & PT
Buttonbush Cephalanthus occidentalis	33 (11)	29	25	Oakland: Orchard Lake, Ward Nature Center	PT
+Catalpa, northern Catalpa speciosa	*239 (76)	98	95	Ingham: Lansing, Capitol grounds	PT
+Catalpa, southern C. bignonioides	202 (64)	75	67	Kent: Sparta, 101 W Division St	C. Kurtz & H. Harvey
Cherry, choke P. virginiana	*69 (19)	67	63	Kent: Ada, Community Park	PT
Cherry, pin P. pensylvanica	38 (12)	45	30	Huron: S of Harbor Beach, Wegener Park	HN
+Cherry, sour P. cerasus	*119 (38)	68	75	Calhoun: 3 mi N of Homer, 7821 22 Mile Rd	PT

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
+Cherry, sweet P. avium	122 (39)	65	78	Oakland: Bloomfield Hills, Cranbrook	PT
Cherry, wild black Prunus serotina	*191 (61)	136	138	Washtenaw: S of Ypsilanti, N end of Pineview Rd	R. Giles, PT, & A. Kerle
	*219 (70)	93	123	Allegan: NE of Saugatuck, 65th St & 135th Ave	HN
+Chestnut, American Castanea dentata	219 (70)	55	73	Grand Traverse: Old Mission Peninsula, 18529 Mission Rd	H. Harvey
Coffeetree, Kentucky Gymnocladus dioicus	*165 (53)	110	108	Van Buren: Hartford, 409 S Haver St	PT
Cottonwood Populus deltoides	319 (102)	148	160	Wayne: Wayne, N of Sims & Michigan Ave	F. Walker & PT
+Cucumbertree Magnolia acuminata	148 (47)	75	93	Berrien: S of Dayton, 3110 Spirea Rd	J. Kidder & PT
+Dogwood, flowering Cornus florida	46 (15)	52	52	Lenawee: Morenci, Cemetery at N end	PT
Dogwood, gray C. foemina	*18 (5.7)	37	22	Oakland: Birmingham, 231 Larchlea Rd	PT
Dogwood, pagoda C. alternifolia	23 (7.3)	41	38	St. Clair: Avoca, Cribbin Rd at Pine River	PT
Dogwood, red-osier C. stolonifera	10 (3.2)	17	18	Benzie: Frankfort, Anderson Rd & M 22	A. Tesaker
Dogwood, round-leaved C. rugosa	*11 (3.5)	40	16	Leelanau: S of Duck Lake	PT
Elder, common Sambucus canadensis	*14 (4.5)	26	18	Leelanau: Cedar City, swamp along railroad	PT
Elder, red-berried S. pubens	*18 (5.7)	22	13	Keweenaw: 2 mi NE of Lac La Belle	J. Wells & PT
Elm, American or white Ulmus americana	213 (68)	123	132	Wayne: Grosse Pointe Farms, 942 Sunnyside Rd	PT
Elm, red or slippery U. rubra	95 (30)	90	54	Leelanau: Sleeping Bear Dunes, top of Pyramid Point	PT
Elm, rock or cork U. thomasii	90 (29)	91	66	Grand Traverse: Kingsley, 5 mi E	H. Harvey
+Elm, September U. serotina	*98 (31)	71	70	Wayne: Trenton, Elizabeth Park	HN
+Elm, Siberian U. pumila	*177 (56)	122	147	Oakland: Rochester, Romeo & Parkway Sts	HN
Fir, balsam Abies balsamea	*84 (27)	116	33	Ontonagon: Porcupine Mountain State Park, Government Peak Trail	PT
+Fir, white A. concolor	76 (24)	76	24	Oakland: Bloomfield Hills, 111 Lone Pine Rd	J. Wells & PT
+Fringetree Chionanthus virginicus	24 (7.6)	18	25	Grand Traverse: Traverse City State Hospital	PT
+Ginkgo Ginkgo biloba	134 (43)	94	70	Hillsdale: Hillsdale City Library	H. Cordrey
Hackberry Celtis occidentalis	*248 (79)	126	112	Allegan: Wayland, 10th St & 132nd Ave	G. Merren & PT
Hawthorn, dotted Crataegus punctata[3]	50 (16)	39	52	Oakland: Bloomfield Hills, Guilford Rd	PT
Hawthorn, downy C. mollis[3]	*105 (33)	52	62	Wayne: Grosse Ile, 8120 Macomb St	PT
Hawthorn, fleshy C. succulenta[3]	26 (8.3)	42	42	Keweenaw: Delaware, Montreal River	PT

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
Hemlock, eastern Tsuga canadensis	164 (52)	127	50	Marquette: Huron Mountain Club (Big Bay)	J. Rice
	164 (52)	121	62	Emmet: S of Cross Village	S. Graham & PT
Hickory, bitternut Carya cordiformis	170 (54)	101	79	Shiawassee: 4 mi N of Owosso, Country Club	N. Bach & PT
	*147 (47)	134	111	Cass: Marcellus, Burlington Rd	L. Lewis & PT
Hickory, pignut C. glabra	144 (46)	70	60	Ingham: 2 mi W of Stockbridge	HN
Hickory, shagbark C. ovata	136 (43)	76	38	Calhoun: NW of Marshall, Baker Sanctuary	H. Harvey
Highbush cranberry Viburnum trilobum	*18 (5.7)	25	25	Wayne: Trenton: Elizabeth Park	PT
	*10 (3.2)	32	31	Wayne: Grosse Ile, Westcroft Gardens	PT
Holly, Michigan Ilex verticillata	10 (3.2)	17	14	Washtenaw: NW of Chelsea, Long Lake	PT
Holly, Mountain Nemopanthus mucronatus	*13 (4.1)	20	10	Oakland: NW of Highland, Fish Lake	PT
Hoptree or wafer ash Ptelea trifolia	*33 (11)	35	40	Kent: Ada, Community Park	C. Rogers & PT
+Horse-chestnut Aesculus hippocastanum	189 (60)	77	85	Washtenaw: W of Ann Arbor, 10395 Jerusalem Rd	C Redderman & PT
Ironwood or hop-hornbeam Ostrya virginiana	*112 (36)	73	88	Grand Traverse: Monroe Center, Miller Rd	A. Tesaker
Juniper, common Juniperus communis	*17 (5.4)	18	8	Leelanau: Glen Haven, Sleeping Bear Dunes National Lakeshore	PT
Larch, eastern Larix laricina	105 (33)	69	64	Lake: Luther, Pond 1 mi E	J. Beurge
+Larch, European L. decidua	124 (39)	84	90	Lenawee: 0.25 mi E of Macon, Macon Rd	D. Minick
+Lilac, common Syringa vulgaris	42 (13)	29	21	Mackinac: Mackinac Island, Market St	PT
Locust, honey Gleditsia triacanthos	*216 (69)	115	124	Wayne: Grosse Ile, 245 E River Rd	C. Bauman & PT
Locust, thornless honey G. triacanthos f. inermis	*193 (61)	113	99	Lenawee: W of Adrian, Seneca Rd & Highway M 34	R. Smith & PT
Magnolia, cucumber (see cucumbertree)					
+Locust, black Robinia pseudoacacia	221 (70)	96	85	Hillsdale: 7 mi NW of Pittsford, 1334 Stewart Rd	H. Hoppe & PT
Maple, black Acer nigrum	*198 (63)	118	127	Allegan: Allegan, Thomas & Jackson Sts	HN & PT
Maple, mountain A. spicatum	33 (11)	58	31	Houghton: 2 mi SE of Beacon Hill	R. Kreutzer & Pat Thompson
+Maple, Norway A. platanoides	138 (44)	104	102	Wayne: Grosse Pointe Farms, Lakeshore Dr S of Moran Rd	HN
Maple, red A. rubrum	*222 (71)	179	120	St. Clair: St. Clair, 6700 Puttygut Rd	PT
Maple, silver A. saccharinum	*276 (88)	125	134	Oakland: N of Rochester, 405 Stony Creek Rd	HN
Maple, striped A. pensylvanicum	44 (14)	59	43	Marquette: Huron Mountain Club, Rush Lake Trail	C. Gale, PT, & D. Bingham
Maple, sugar or hard A. saccharum	205 (65)	102	102	Leelanau: S of Lake Leelanau Village, Co. Highway 645 0.9 mi S of M 204	J. Spencer

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
Mountain-ash, American *Sorbus americana*	62 (20)	57	34	Keweenaw: Louis Bay on Keweenaw Bay	L. Berndt
+Mountain-ash, European *S. aucuparia*	48 (15)	45	35	Benzie: Beulah, along US-31	PT
Mountain-ash, showy *S. decora*	*57 (18)	58	32	Mackinac: 7 mi S of Gould City	W. Mahalak
+Mulberry, red *Morus rubra*	*224 (71)	72	98	Berrien: Bridgman, Jericho & Shawnee Rds	D. Savage & PT
+Mulberry, white *M. alba*	*251 (80)	75	79	Lenawee: E of Morenci, 5600 E Mulberry	PT
Nannyberry *Viburnum lentago*	*34 (11)	40	40	Oakland: Bloomfield Hills, N of Cranbrook	PT
Oak, black *Quercus velutina*	*246 (78)	127	137	St. Clair: Algonac, Washington & Clay Sts	HN & PT
Oak, bur *Q. macrocarpa*	268 (85)	110	130	Berrien: Niles, 702 Chippewa Trail	PT
+Oak, English *Q. robur*	155 (49)	81	76	Benzie: Benzonia, Case & Homestead Rds	A. Tesaker
Oak, northern pin *Q. ellipsoidalis*	139 (44)	91	93	Oakland: S of Lake Orion, Bald Moutain Rd.	PT
Oak, pin *Q. palustris*	159 (51)	112	106	Wayne: Trenton, 22310 Telegraph Rd	PT
Oak, red *Q. rubra*	268 (85)	115	139	Allegan: Saugatuck, 329 St. Joseph St	HN & PT
Oak, scarlet *Q. coccinea*	156 (50)	92	102	St. Clair: Port Huron, Riverside Park	PT
Oak, shingle *Q. imbricaria*	139 (44)	91	99	Calhoun: SW of Albion, 22 Mile Rd & D Dr S	PT
Oak, swamp white *Q. bicolor*	*232 (74)	139	134	Wayne: Grosse Ile, Bridge & Meridian Rds	PT PT
Oak, white *Q. alba*	255 (81)	134	161	Allegan: Allegan, 1308 Ely St	HN & PT
Oak, yellow chestnut *Q. muehlenbergii*	190 (60)	119	124	Washtenaw: Ann Arbor, Wurster Park	E. Gallup & PT
+Osage-orange *Maclura pomifera*	168 (53)	50	45	Berrien: Coloma, edge of town	C. Nelson
Pawpaw *Asimina triloba*	*35 (11)	48	32	Macomb: S of Utica, Sterling Heights Park	PT
+Pear *Pyrus communis*	*136 (43)	55	56	Wayne: Dearborn Heights, 24600 Ann Arbor Trail	HN & PT
	*118 (38)	67	68	Wayne: Wayne, 2650 Hannon Rd	HN & PT
+Pagoda, Japanese *Sophora japonica*	136 (43)	102	110	Monroe: Monroe, Elm St & US 25	HN
+Persimmon *Diospyros virginiana*	70 (22)	69	47	Kent: Grand Rapids, 1715 N Center St	H. Clark
+Pine, Austrian *Pinus nigra*	100 (32)	87	82	Lenawee: E of Tecumseh, 8447 Ridge Rd	PT
Pine, jack *P. banksiana*	*91 (30)	84	50	Marquette: 16 mi S of Marquette	J. Wells, PT, B. Spike & G. Fons
Pine, red *P. resinosa*	*123 (39)	154	96	Gogebic: Sylvania Tract, NE of Loon Lake	PT
+Pine, Scotch *P. sylvestris*	*186 (59)	64	76	Lenawee: Sand Creek, Sand Creek Rd	HN & PT

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
Pine, white *P. strobus*	*186 (59)	201	63	Marquette: Huron Mountain Club, Fisher Creek Trail	PT
	*202 (64)	181	64	Marquette: Huron Mountain Club, Fisher Creek Trail	PT
	237 (75)	125	48	Keweenaw: S of Copper Harbor Estivant Pines, Montreal River	J. Rooks & PT
Plum, American or wild *Prunus americana*	*36 (11)	35	35	Oakland: S edge of Lakeville Swamp	PT
Plum, Canada *P. nigra*	*50 (16)	51	49	Macomb: S of Utica, Sterling Heights Park	PT
Poplar, balsam *Populus balsamifera*	*162 (52)	138	92	Marquette: Champion, US 41	HN & PT
+Poplar, Lombardy *P. nigra* 'Italica'	*186 (59)	73	37	Chippewa: Sault St. Marie, Bingham & Easterday Rds	HN
+Poplar, silver *P. alba*	239 (76)	86	112	Charlevoix: S of Charlevoix 2 mi, Barnard Rd	PT
Prickly-ash *Zanthoxylum americanum*	15 (4.8)	16	14	Lenawee: S of Tecumseh, E of Raisin Center & Ives Rds	R. Smith
	*12 (3.8)	28	34	Oakland: Beverly Hills, Douglas Park	PT
Redbud *Cercis canadensis*	66 (21)	30	38	Berrien: Buchanan, 455 Moccasin Dr	S. Beikman
Red-cedar, eastern *Juniperus virginiana*	90 (29)	50	42	Grand Traverse: N of Williamsburg, Cram Rd	H. Harvey
+Russian-olive *Elaeagnus angustifolia*	115 (37)	58	59	Oakland: Bloomfield Hills, 459 Martell	PT
Sassafras *Sassafras albidum*	182 (58)	78	54	Jackson: Jackson, 1318 Coddington Lane	J. Ellison & PT
Serviceberry, Allegheny *Amelanchier laevis*	*62 (20)	60	59	Isabella: Blanchard, Stamm Farm	PT
Serviceberry, downy *A. arborea*	*79 (25)	63	74	Barry: 4 mi SE of Cloverdale, 425 Pritchardville Rd	K. Jones & PT
Serviceberry, roundleaf *A. sanguinea*	16 (5.1)	38	20	Keweenaw: Copper Harbor, 1 block W of Fort Wilkins	PT
Shadbush (see Serviceberry)					
+Smoketree *Cotinus coggygria*	32 (10)	31	31	Oakland: Ferndale, 1728 Pinecrest Rd	PT
Spicebush *Lindera benzoin*	*10 (3.2)	23	18	Wayne: Detroit, Belle Isle	HN
+Spindle tree *Euonymus europaea*	*22 (7.0)	32	29	Oakland: Birmingham, Brookdate & Minor Rds	J. Wells & PT
Spruce, black *Picea mariana*	57 (18)	63	39	Isabella: Farwell, S of Herrick Rd	PT
+Spruce, Norway *P. abies*	145 (46)	98	78	Oakland: Novi, 21937 Novi Rd	PT
Spruce, white *P. glauca*	104 (33)	102	32	Marquette: Huron Mountain Club, Rush Lake	R. Waterman, C. Denby & PT
Sumac, poison *Toxicodendron vernix*	15 (4.8)	31	30	Oakland: Swamp S of Lakeville	PT
Sumac, shining *Rhus copallina* 'latifolia'	*28 (8.9)	33	20	Kalamazoo: Vicksburg, Prudential Nursery	PT
Sumac, staghorn *R. typhina*	29 (9.2)	49	30	Oakland: Orchard Lake, Apple Island	PT
+Sweetgum *Liquidambar styraciflua*	94 (30)	72	69	Wayne: Detroit, Fort & Woodmere Sts	HN

Name of Tree	Girth[1] (Dia.) (in)	Height (ft)	Crown Spread (ft)	County: Location	Observer[2]
Sycamore Platanus occidentalis	292 (93)	161	150	Lenawee: Adrian, N of Riverside park	HN & PT
Tulip-tree Liriodendron tulipifera	177 (56)	171	133	Cass: near Russ Forest, 10 mi E of Dowagiac	PT
Tupelo or Black-gum Nyssa sylvatica	140 (45)	77	80	Cass: Marcellus, Wright & Burlington Rds	L. Lewis
Walnut, black Juglans nigra	232 (74)	118	116	Macomb: New Haven, 56505 Omo Rd	H. Hinz
White-cedar Thuja occidentalis	*216 (68)	113	42	Leelanau: S Manitou Island, Valley of the Giants	PT
+Willow, autumn Salix serissima	*35 (11)	48	44	Oakland: Birmingham, Northlawn & Cranbrook Rds	PT
Willow, Bebb's or beaked S. bebbiana	*18 (5.7)	36	38	Leelanau: Cedar City, along railroad	PT
Willow, black S. nigra	*337 (107)	90	96	Grand Traverse: Traverse City State Hospital	H. Harvey
	*323 (103)	96	116	Washtenaw: Ann Arbor, 227 Barton Shore	PT
+Willow, brittle or crack S. fragilis	*309 (98)	110	153	Oakland: Beverly Hills, Douglas Park	PT
	*305 (97)	122	124	Macomb: NW of Utica, Utica Recreation Area	HN & PT
Willow, meadow or slender S. petiolaris	*13 (4.1)	34	18	Leelanau: Little Traverse Lake, E shore	PT
Willow, peach-leaved S. amygdaloides	61 (19)	112	42	Macomb: S of Utica, Sterling Heights Park	PT
+Willow, purple-osier S. purpurea	*15 (4.8)	37	49	Leelanau: W of Omena, Putman Rd & Co-629	PT
+Willow, pussy S. discolor	*54 (17)	47	33	Clinton: St. Johns, 715 S Lansing St	C. Smith & PT
Willow, sandbar S. interior	*25 (8.0)	36	23	Macomb: NW of Utica, Utica Recreation Area	PT
Willow, shining S. lucida	*130 (41)	74	81	Grand Traverse: Traverse City State Hospital	PT
+Willow, weeping S. babylonica	*254 (81)	128	123	Wayne: Grosse Pointe, 4594 Hereford Rd	PT
	*271 (86)	117	116	Wayne: Detroit, 886 Ashland St	M. Kropp
+Willow, white S. alba	*316 (101)	118	131	Oakland: W of New Hudson, Glynn Ct & Pontiac Trail	PT
Witch-hazel Hamamelis virginiana	*17 (5.4)	41	41	Muskegon: Muskegon State Park	PT
+Yellowood Cladrastis lutea	*177 (56)	80	96	Washtenaw: Ann Arbor, 227 Barton Shore Dr	PT

Footnotes

+ Exotic species, native species outside natural range, or planted individuals

*National Champion

[1]Values in parentheses are dbh in inches.

[2]HN = Harold Nett; PT = Paul W. Thompson

[3]Identified by expert: Betula cordifolia, S. A. Cain; Crataegus spp., E. J. Palmer

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FOSSOMBRONIA AND THE MYSTERY OF SPORE DISPERSALS

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The rarity of some bryophytes may be more apparent than real. They are small and unobtrusive, and there are few who care to look for them. It is amusing to plot the distributions of even common species on maps. They seem to flourish in the vicinity of institutions of higher learning and especially those with bryological representation. And so it is in Michigan. It is perfectly true that the area of the University of Michigan Biological Station is bryologically well known. Yet, over the many years that I have been there as student and teacher, I continue to find interesting additions to the flora and new localities for rarities. There has been a continuity of bryological activity in the region of the Straits of Mackinac since 1918 when George Nichols visited there in search of a good source of *Sphagnum* for use as wartime surgical pads. A number of keen-eyed and enthusiastic bryologists, teachers, students, and investigators, have been there looking. In an area so recently covered by glacial ice and meltwater and so limited in habitat diversity, one wonders how rarities continue to be found. Are they recent invaders brought in by the wind and other vectors of accidental dispersal? Or have they slowly moved into the area in the wake of glacial retreat? The answer is not likely to be found, yet there are good reasons for doubting that spores are effectively carried long distances entirely by chance.

Because bryophytes have decided habitat preferences and occupy the same ranges that higher plants with heavy seeds and fruits do, it seems logical to assume that they move slowly, step by step, with the associations of plants to which they belong, with the plants that make the habitats that they occupy. It is true that the spores are small and could be blown long distances by the wind, but are they likely to be caught up above the herb and shrub layer in which they find shelter? Can they survive the extremes of heat and cold, not to mention drought and ultraviolet radiation to which they would be subjected in the upper atmosphere where winds are persistently directional in contrast to the cyclonic, turbulent, gusty winds lower down? Are they not likely to be salted out by moisture condensation? Can we expect them to fall in the right place, at the right time, and be free of competition? Certainly the spores are produced in the millions, and some chance of an odd spore reaching just the right niche and thriving in it does exist. How else have volcanic islands recently emergent from the sea, like the Hawaiian Islands, been populated? But how improbable it is on continental land masses where all the niches are most likely closed, already occupied by native or thoroughly naturalized species. Also continental landforms block winds, giving no clean sweep to the wild storms that wreak havoc in oceanic areas.

Certain it is that disturbances create temporary habitats quickly filled by aggressive species, or downright weeds, most probably of local origin. If the habitat permits, even less aggressive species can occupy the niche. Such a species might be exemplified by *Fossombronia foveolata* Lindb., a liverwort of ruffled appearance that is very rare in the area of the Upper Great Lakes. It has been found in two localities in Cheboygan County (where the University of Michigan Biological Station is located) and one in nearby Presque Isle County. Across the Straits, and at a considerable distance, it has been collected in Alger and Marquette (or possibly Baraga) Counties. On August 13, 1985 I found a sparse growth on bare patches of wet sand at the bottom of a roadside ditch in Emmet County, which lies immediately west of Cheboygan County. The locality (0.3 mi. E of Brutus on the Brutus Road) is no more than six or seven miles from the nearest known station for the species. The discovery is recorded here because of the rarity of the species and a dearth of habitat information on it.

At Vincent Lake and Duck Marsh (near Lake Sixteen), both in Cheboygan County, the species grows on wet sand (Miller & Crum, 1984). Associated species give some indication of acidic, though relatively mineral-rich conditions. Likewise, in Emmet County, the plants are associated with a waif-and-stray assemblage of plants that are indicative of nutrient availability. The ditch lies at the top of a slope but collects enough water to support a fine show of *Lobelia cardinalis,* as well as *Chamaedaphne calyculata* (a bog species), *Onoclea sensibilis* (a resident of mineral-rich swamps), and *Sphagnum subsecundum* var. *rufescens* (a minerotrophic sedge-fen species). The *Fossombronia* grew on a thin, black crust made up of a teeming population of diatoms of many kinds, as well as some blue-green algae, fewer in number and lesser in mass. Other associates included *Lycopus uniflorus, Spiranthes cernua, Solidago graminifolia,* and *Eupatorium perfoliatum*. The only other

bryophytes present were the moss *Bryum pseudotriquetrum* and the thallose liverwort *Aneura pinguis,* both indicators of wet, base-rich substrates.

Capsules were produced in culture, and mature spores were seen, together with bispiral elaters, on October 2. The spores are 36–48 μm in longer diameter—a size not conducive to wind dispersal. The spores of most bryophytes are in the range of 8–12 μm and presumably capable of being blown some 12,000 miles, whereas some few have spores about 25–30 μm capable of being dispersed 200 miles. The spores of *Fossombronia* are, of course, considerably larger and produced in shelter, virtually adnate to wet soil, where they are unlikely to dry out and unlikely to be windswept out of their depressed habitats. Most probably the spores came from nearby, but the vector is not likely to be wind, nor are birds likely to carry coarse sand or stray spores on their bills and feet or among their feathers.

The dispersibility of bryophyte spores and the phytogeographic significance of bryophyte distributions is a good subject for armchair philosophers, but it would be better to trap spores from rain and snow or dry fallout and see if they germinate and, if so, try to determine where they came from, close by or far away. This should be done as a final test of whether distributions of spore-bearing plants have the historical significance in terms of origin and migration that the similar ranges of higher plants presumably have. This kind of work has been done for fungi (Gregory, 1961), especially epidemic pathogens, but not for green cryptogams.

It is not the purpose of this paper to give an exhaustive account of the dispersal vectors or to answer for all time the questions that plant dispersals and distributions bring to mind. Some consideration of these questions and some attempt to provide answers were included in a symposium paper that I presented in Tokyo in 1971. Persons with piqued curiosities might well look at that paper and other papers cited in its bibliography. My only purpose at the moment is to report one significant example of a dispersal not easily explained. I would hope that persons not involved in reporting range extensions (I saw a blue bird, so what?) will see why they interest me.

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BOUTELOUA GRACILIS, A NEW GRASS TO MICHIGAN

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In early September of 1984, we observed a grama grass in the dry, sandy soil of the lawn on the south side of the Education Building at Wurtsmith Air Force Base, Iosco County (Oscoda Twp., T24N, R9E, Sec. 28, NW¼). Later, when we returned to collect specimens, the entire area had been mowed. Teaching again at the base the following summer, we patiently watched the area for flowering culms. We were able to collect *Bouteloua gracilis* (H.B.K.) Lag. from the same colony on July 30 and August 6, 1985 [Russ Garlitz 1278 (MICH) and 1296 (BLH, GH, MICH, MSC)], when we found two patches, each about one meter square and each bearing about 80 fertile culms (Fig. 1). Two hours of searching in the area turned up no other plants.

Wurtsmith Air Force Base was established more than thirty years ago on relic dunes that line the north bank of the Au Sable River near its outlet on the Lake Huron shore. After years of disturbance on this sandy soil, the lawn flora includes many xerophytic remnants such as Big and Little Bluestem, Indian Grass, Three-leaved Cinquefoil, and roadside patches of Beach-Heath (*Hudsonia tomentosa*). Many adventives are also abundant here, such as *Bromus squarrosus, Bromus tectorum, Scleranthus annuus* (Knawel), *Trifolium arvense* (Rabbitfoot Clover), and *Verbena bracteata* (Bracted Verbena). The location of *Bouteloua gracilis* on the base is within one-half mile of the main landing strip at this active B-52 bomber base and planes arrive frequently from all parts of the country. We think it unlikely that the plant was introduced in grass seed mixture, but more likely that it arrived from the West in crating or containers that are shipped from one base to another.

Bouteloua gracilis is reported to be naturalized locally in the northeastern United States (Hitchcock 1951, Fernald 1950, and Gleason & Cronquist 1963). The plant is not reported for Michigan in Voss (1972), and we found no specimens in the herbaria of MICH or MSC. Inquiry to the curators of BLH and WMU revealed no specimens. This, we believe, is the first published report of this species in Michigan.

We wish to thank Dr. Anton Reznicek, University of Michigan Herbarium, for help in confirming the identification of the plant and for encouragement and suggestions in the preparation of this article.

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Fig. 1. *Bouteloua gracilis* at Wurtsmith Air Force Base.

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JAPANESE HONEYSUCKLE INVASION

The Japanese Honeysuckle (*Lonicera japonica* Thunb.), one of the most pernicious weeds of North America, is now entering and spreading into Michigan and adjacent states. During the past twenty years I have discovered populations forming colonies at forest edges, along roadsides and trails, and even in the sand dunes. A serious pest in southeastern United States, Japanese Honeysuckle is currently making its way northward and becoming established and reproducing. I now have collections of wild populations from fourteen counties of southern Michigan. We are trying to monitor its spread, and we need your help in two ways: (1) Don't encourage this dangerous plant by growing it in your yard, and tell your neighbors not to either. If you avoid using it in your garden, you will lessen the chances of spreading it by its bird-carried fruits. (2) If you encounter spontaneous colonies of this plant (easily recognized by its trailing and climbing habit; leaves opposite, semi-evergreen; stems 2–3 mm. thick, finely hairy, sometimes brown-pigmented; flowers in June, white and extremely fragrant; fruit in August and September, berry-like, shiny black) please let us know of their whereabouts.

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25

THE VEGETATION AND FLORA OF THE NORDHOUSE DUNES, MANISTEE NATIONAL FOREST, MASON COUNTY, MICHIGAN. II. CATALOGUE OF VASCULAR PLANTS

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The history and present vegetation of the Nordhouse Dunes have been described in an earlier paper (Hazlett 1986). As was stressed in that paper, these dunes and their diverse habitats occur in a floristically unexplored coastal region between the Sleeping Bear dunes and nearby islands, and the southeastern end of the lake. Many vegetation studies have been done on Lake Michigan dunes, but very few (Peattie 1930; Hazlett & Vande Kopple 1983) have included a detailed species list. Other floras in this part of the state include Daniels (1904) for Manistee and vicinity, and Mustard (1983) for another section of Manistee National Forest, predominately in Oceana Co.

This floristic survey of the Nordhouse Dunes is an important contribution in the representation of Mason Co. in the state flora. Sixty-four species of gymnosperms and monocots found during this study were not recorded for the county by Voss (1972). Many of these records must reflect limited botanical collecting since common grasses such as *Agropyron repens* and *Phleum pratense* were new records, and only 6 of the 35 species of Cyperaceae found during this study had been previously documented in the county. Significant northern range extensions can be noted for *Carex howei* and *Eleocharis engelmannii* as well as a southern range extension for the western disjunct, *Goodyera oblongifolia*.

The floristic composition of the Nordhouse area includes a mixture of northern and southern elements in an area which, geographically, could be included in the tension zone (Potzger, 1948). *Nyssa sylvatica, Sassafras albidum, Rhus copallina,* and, to a lesser extent, *Quercus velutina* are a few excellent examples of southern woody species. Conversely, northern woody species include *Pinus banksiana, P. resinosa, Picea mariana,* and *Taxus canadensis*. *Taxus canadensis* is rare perhaps in part due to extensive deer browse.

Pitcher's thistle (*Cirsium pitcheri*) was the only Michigan threatened species encountered during this study. This species is doing remarkably well on the open dunes despite the previous ORV activity here. In the jack pine stands, ram's-head lady-slipper (*Cypripedium arietinum*) and spotted wintergreen (*Chimaphila maculata*), species now listed as of special concern in Michigan, were found. Tooth cup (*Rotala ramosior*), another special concern species, was found on the mud flats of Nordhouse Lake. Other species with special status may yet be found. Broomrape (*Orobanche fasciculata*), an-

other threatened species, was found on the dunes of Sec. 33 after the main fieldwork.

The following catalogue of 72 families, 232 genera, and 365 species was derived primarily from extensive field work during 1979 and 1980. *Asclepias incarnata,* due to insufficient material in the field, is not supported by a voucher deposited at MICH or MSC. *Scirpus smithii* and *Agrostis gigantea* are also not supported by vouchers, but were identified from scraps attached to specimens sent to MICH. *Betula alleghaniensis* and *Populus nigra* were overlooked in 1979, but were collected in 1985. *Arctium minus* has become established at the end of Nurnburg Rd. sometime during the last six years. The largest family, Compositae, consists of 33 species. *Carex,* the largest genus has 23 species. Nomenclature generally follows Mickel (1979) for pteridopytes, Voss (1972) for gymnosperms and monocots, and Gleason & Cronquist (1963) for dicots not covered by Voss (1985). The families within each major group and then the species within each family are listed alphabetically. Common names are included as well as known flowering times (in parenthesis) based on field observations. Abundance estimates follow Voss (1972). All collection numbers are my own.

CATALOGUE OF VASCULAR PLANTS

PTERIDOPHYTES

EQUISETACEAE (Horsetail Family)

Equisetum arvense L., Field horsetail. Common in moist jack pine stands and between foredune and wooded slope. *859, 908.*

E. hyemale L., Scouring-rush. Common in moist jack pine stands and between the foredune and wooded slope. *858, 909.*

E. sylvaticum L., Woodland horsetail. Frequent in moist to wet shaded areas. *370, 837.*

LYCOPODIACEAE (Clubmoss Family)

Lycopodium clavatum L., Ground pine. Frequent in mixed deciduous woods. *946.*

L. complanatum L., Northern running-pine. Frequent in mixed deciduous woods. *945.*

L. annotinum L., Shining clubmoss. Local under sugar maples in the rich mixed deciduous woods of Sec. 26. *978.*

L. obscurum L., Tree clubmoss. Frequent in mixed deciduous woods and aspen stands. *919.*

OPHIOGLOSSACEAE (Adder's-tongue Family)

Botrychium matricariifolium (Doll) A. Braun, Daisy-leaved grape-fern. Rare, only found in mixed deciduous woods. *849.*

B. simplex E. Hitchc., Little grape-fern. Local in lowland hardwoods. *589.*

B. virginianum (L.) Sw., Rattlesnake fern. Frequent in mixed deciduous woods, cedar swamp, and on wooded bank behind foredune. *584, 824.*

OSMUNDACEAE (Royal Fern Family)

Osmunda cinnamomea L., Cinnamon fern. Common in both mixed deciduous and lowland hardwoods and around bog edges. *439, 478.*

O. claytoniana L., Interrupted fern. Rare, only found in lowland hardwoods. *775.*

O regalis L., Royal fern. Frequent along bog edges. *479, 797.*

POLYPODIACEAE (Polypody Family)

Adiantum pedatum L., Maidenhair fern. Rare. just one small population found in mixed deciduous woods south of meadow. *933.*

Athyrium filix-femina (L.) Roth, Lady fern. Frequent in mixed deciduous, lowland hardwoods, and open sites. *805.*

Dryopteris intermedia (Muhl. ex Willd.) Gray, Evergreen wood-fern. Frequent in mixed deciduous woods and on hummocks in wet sites. *982.*

D. spinulosa (O. F. Muell.) Watt, Spinulose wood-fern. Frequent in mixed deciduous woods and on hummocks in wet sites. *703, 768.*

Gymnocarpium dryopteris (L.) Newm., Oak fern. Occasional in wet sites in mixed deciduous woods and cedar swamp. *422, 771, 880.*

Matteuccia struthiopteris (L.) Todaro, Ostrich fern. Occasional in lowland hardwoods east of Nordhouse Lake. *867.*

Onoclea sensiblis L., Sensitive fern. Common in shady moist and wet sites. *947.*

Polypodium virginianum L., Common polypody. Rare, one small patch found on wooded slope behind foredune. *921.*

Pteridium aquilinum (L.) Kuhn, Bracken fern. Abundant herbaceous cover in oak woods, roadsides, and open sites. *443, 590, 776.*

Thelypteris noveboracensis (L.) Nieuwl., New York fern. Frequent in mixed deciduous woods. *822, 903.*

T. palustris Schott, Marsh fern. Common on edges of ponds and wet areas including cedar swamp. *803, 823, 992.*

T. phegopteris (L.) Slosson, Northern beech-fern. Local on hummocks in lowland hardwoods east of Nordhouse Lake. *881.*

Woodwardia virginica (L.) J. E. Smith, Virginia chain-fern. Common on bogs and pond edges. *932.*

GYMNOSPERMS

CUPRESSACEAE (Cypress Family)

Juniperus communis L., Common juniper. Common at the border of forests with blowout and open sand. *632.*

Thuja occidentalis L., White cedar. Common in moist sites such as the cedar swamp, some jack pine stands, and in the trough between the foredune and wooded slope. *795.*

PINACEAE (Pine Family)

Larix laricina (Du Roi) K. Koch, Larch, Frequent in bogs. *799.*

Picea mariana (Mill.) BSP., Black spruce, Occasional in bogs. *955.*

Pinus banksiana Lamb., Jack pine. Abundant on low relief dunes and old dune ridges. *793.*

P. resinosa Ait., Red pine. Abundant in plantations and around bogs of the marginal sand apron. *940.*

P. strobus L., White pine. Common as understory in oak woods and frequent in red pine forests. *918.*

Tsuga canadensis (L.) Carr., Hemlock. Frequent in mixed deciduous woods and cedar swamp. *716.*

TAXACEAE (Yew Family)

Taxus canadensis Marsh., Yew. Rare, only small clumps protected by logs in the deciduous forest islands on the dunes of Sec. 33. *760.*

MONOCOTYLEDONS

ALISMATACEAE (Water-plantain Family)

Alisma plantago-aquatica L., Water-plantain (mid, July-early Aug.). Local on mud flats around Nordhouse Lake. *693.*

ARACEAE (Arum Family)

Arisaema triphyllum (L.) Schott, Jack-in-the-pulpit (mid May–early June). Frequent in lowland hardwoods, moist shaded sites, and cedar swamp. *308, 323.*

Calla palustris L., Water-arum. Local in bog-swamp near Lost Lakes. *980, 989.*

CYPERACEAE (Sedge Family)

Carex arctata Boott, common in moist sites between wooded bank and foredune. *576b, 580.*

C. argyrantha Tuckerm., occasional in open sites. *486.*

C. bebbii (Bailey) Fern., occasional in moist woods. *761.*

C. brunnescens (Pers.) Poir., frequent in wet shaded sites. *670, 707.*

C. buxbaumii Wahl., occasional in moist sites near open dune margin. *435.*

C. crinita Lam., common in wet open sites and edges of bogs and ponds. *379a, 440, 489, 583.*

C. cryptolepis Mack., local in grassy margin surrounding Nordhouse Lake. *950.*

C. debilis Michx., occasional in moist woods. *709.*

C. eburnea Boott, occasional to moist area between foredune and wooded bank. *581.*

C. flava L., occasional in moist open sites and near dune pools. *649.*

C. folliculata L., common in wet woods and bogs. *358, 367, 378, 452, 708.*

C. interior Bailey, occasional in wet shaded sites. *373.*

C. howei Mack. (*C. atlantica* ssp. *capillacea*), frequent in moist sites of powerline clearing Sec. 25. *476.*

C. intumescens Rudge., common in bogs and wet open sites. *378a, 483, 604.*

C. lanuginosa Michx., occasional in meadow. *560.*

C. lupulina Willd., common in open wet sites and alder thickets. *469, 602, 868.*

C. merritt-fernaldii Mack., local in ditch along Nurnburg Rd., Sec. 36. *508.*

C. oligosperma Michx., occasional in bogs. *665.*

C. pensylvanica Lam., abundant on forested dune ridges and occasional in mixed deciduous woods. *702, 974, 979.*

C. rostrata Stokes, frequent in mixed deciduous woods and moist open sites. *672, 871.*

C. tribuloides Wahl., occasional in lowland hardwoods. *761.*

C. trisperma Dewey, occasional in moist shaded sites. *449, 718.*

C. tuckermanii Dewey, local in moist to wet woods. *769, 930.*

C. viridula Michx., local on dune pannes. *749.*

Cyperus schweinitzii Torr., frequent on grassy dunes. *743.*

Dulichium arundinaceum (L.) Britt., Three-way sedge. Frequent on pond edges and in lowland hardwoods. *825, 872.*

Eleocharis acicularis (L.) R. & S., local on mudflats of Nordhouse Lake. *688.*

E. elliptica Kunth, local in meadow and dune pools. *350, 985.*

E. engelmanii Steud., local on mud flats of Nordhouse Lake. *687.*

E. smallii Britt., local on mud flats of Nordhouse Lake. *942.*

Eriophorum virginicum L., common in bogs. *819.*

Scirpus americanus Pers., Three-square. Occasional in dune pools and wet areas of the open dunes of Secs. 32 and 33. *852.*

S. atrovirens Willd., common in bogs and wet open sites. *468, 569, 592, 663, 674.*

S. cyperinus (L.) Kunth, common in pools and lowland hardwoods and bogs. *777, 813, 869b.*

S. smithii Gray, local on the shores of Nordhouse Lake.

GRAMINEAE (Grass Family)

Agropyron repens (L.) Beauv., Quack grass. Common in open sites and roadsides. *446, 500, 640.*

A. trachycaulum (Link) Malte, frequent in clearcut. *515.*

Agrostis gigantea Roth.

A. hyemalis (Walt.) BSP., Tickle grass. Frequent on dune pannes and near Nordhouse Lake. *689, 816.*

A. perennans (Walt.) Tuckerm., frequent in moist open sites and roadsides. *614, 897.*

Ammophila breviligulata Fern., Beach grass. Abundant on grassy dunes. *634.*
Andropogon scoparius Michx., Little bluestem. Frequent on grassy dunes. *818.*
Brachyelytrum erectum (Roth) Beauv., occasional in mixed deciduous woods. *706.*
Bromus inermis Leysser, Smooth brome. Common along roadsides. *383, 514, 544.*
Calamagrostis canadensis (Michx.) Beauv., Blue-joint. Common in wet open sites and bogs. *437, 543, 570, 605, 638, 678, 817.*
Calamovilfa longifolia (Hook.) Scribn., abundant on the foredune and recently stabilized dunes. *635.*
Cinna latifolia (Goepp.) Griseb., frequent in lowland hardwoods. *870b.*
Dactylis glomerata L., Orchard grass. Common along roadsides. *450, 512.*
Danthonia spicata (L.) R. & S., Oat grass. Common along roadsides and disturbed and open sites. *499, 507, 603, 641, 675.*
Deschampsia flexuosa (L.) Beauv., Common hairgrass. Common along open trails and in oak woods. *363, 445, 480, 504, 568, 677.*
Elymus canadensis L., frequent on foredune and stable sand near woods. *714, 905.*
Festuca saximontana Rydb., frequent along open trails and roadsides. *545, 571.*
Glyceria borealis (Nash) Batch., Small floating manna grass. Occasional in wet shades sites. *870.*
G. canadensis (Michx.) Trin., Rattlesnake grass. Common in wet shaded sites and near ponds. *601, 869a, 870a.*
G. striata (Lam.) Hitchc., Fowl manna grass. Occasional in moist shaded sites. *576.*
Koeleria macrantha (Ledeb.) Schult., June grass. Frequent on grassy dunes. *434, 820.*
Oryzopsis pungens (Spreng.) Hitchc., occasional in oak woods. *448.*
O. asperifolia Michx., common in mixed deciduous woods. *559, 630, 681.*
Panicum columbianum Scribn., occasional in open two-tracks. *668.*
P. implicatumm Britt., frequent in jack pine stands and in open area around Nordhouse Lake. *619, 684, 738.*
P. latifolium L., occasional in mixed deciduous woods. *503.*
P. meridionale Ashe, occasional in open wet sites. *455.*
P. virgatum L., common in open moist sites including dune pannes. *683, 739, 943.*
Phleum pratense L., Timothy. Frequent along roadsides and open sites. *447, 481, 513.*
Poa compressa L., Canada bluegrass. Common along trails and two-tracks. *639, 642, 664.*
P. palustris L., Fowl meadow grass. Local, only collected at north end of meadow. *639.*
P. pratensis L., Kentucky bluegrass. Common along trails and two-tracks. *472, 594.*
Setaria viridis (L.) Beauv., Green foxtail. Occasional on roadsides. *833.*
Spartina pectinata Link, Slough grass. Common in moist open sites of meadow and around Nordhouse Lake. *637, 686.*

IRIDACEAE (Iris Family)
Iris virginica L., Blue flag. Frequent around Tamarack Lake and bogs and also in alder thickets and ponds. *431, 485, 574, 591, 609.*

JUNCACEAE (Rush Family)
Juncus acuminatus Michx., common in wet open sites and roadsides. *464, 511, 644, 690.*
J. balticus Willd., local in dune pools. *626, 742.*
J. canadensis LaHarpe, occasional in wet open sites. *827.*
J. effusus L., common in open wet sites. *460, 474, 509, 671.*
J. tenuis Willd., Path rush. Frequent in moist open sites. *487, 494, 673.*

JUNCAGINACEAE (Arrow-grass Family)
Triglochin palustre L., local on edges of dune pools. *741, 809.*

LEMNACEAE (Duckweed Family)
Lemna minor L., Duckweed. Local in ponds and alder thickets. *766.*

LILIACEAE (Lily Family)

Clintonia borealis (Ait.) Raf., Corn-lily. Occasional in mixed deciduous woods. *821.*

Erythronium americanum Der., Adder's tongue. Local in rich mixed deciduous woods under sugar maples. *977.*

Lilium philadelphicum L., Wood lily (late June–early July). Rare, a few scattered plants found on foredune Sec. 27. *537.*

Maianthemum canadense Desf., Canada mayflower (June). Occasional in rich deciduous woods bordering open sand. *401.*

Medeola virginiana L., Indian cucumber-root (early–late June). Frequent in mixed deciduous woods and cedar swamp. *347, 371, 562.*

Polygonatum pubescens (Willd.) Pursh, Hairy Solomon's seal. Occasional in mixed deciduous woods. *346, 404.*

Smilacina stellata (L.) Desf., Starry false Solomon's seal. Frequent in border zone between woods and open sand. *402.*

Smilax hispida Torr., occasional in mixed deciduous woods. *767, 948.*

Zigadenus glaucus (Nutt.) Nutt., White camas (mid June–mid July). Frequent in protected sites near jack pine stands. *432, 533.*

ORCHIDACEAE (Orchid Family)

Corallorhiza odontorhiza (Willd.) Nutt., Spotted coral-root (late July–mid Aug.). Occasional in mixed deciduous woods, cedar swamp, and jack pine stands. *846, 865.*

C. trifida Chat., Early coral-root (late May–early June). Local in cedar swamp and on bank behind foredune. *372.*

Cypripedium acaule Ait., Stemless lady-slipper (early May–early June). Frequent in oak woods. *357, 409.*

C. arietinum R. Br., Ram's-head lady-slipper. Local in jack pine stands. *751, 986.*

Goodyera oblongifolia Raf., Giant rattlesnake-plantain (late July–mid Aug.). Rare, jack pine stands only. *864.*

G. pubescens (Willd.) R. Br., Downy rattlesnake-plantain (late July–mid Aug.). Local in rich deciduous woods. *765.*

G. repens (L.) R. Br., Dwarf rattlesnake-plantain (mid July–mid Aug.). Local in jack pine stands and cedar swamp. *808.*

Habenaria clavellata (Michx.) Spreng., Green woodland orchid (mid July–mid Aug.). Occasional in lowland hardwoods. *902.*

H. hyperborea (L.) R. Br., Tall northern bog orchid (July). Local in trough between foredune and wooded bank. *575.*

H. lacera (Michx.) Lodd., Ragged fringed orchid (early July–early Aug.). Local in mixed deciduous woods. *700.*

Listera cordata (L.) R. Br., Heart-leaf twayblade. Rare, only in cedar swamp. *991.*

Spiranthes cernua (L.) Rich., Common lady's-tresses (late Aug.–early Sept.). Local, cluster of plants found along Nurnburg Rd., and in jack pine stands. *894.*

POTAMOGETONACEAE (Pondweed Family)

Potamogeton gramineus L., local in Nordhouse Lake. *839.*

TYPHACEAE (Cat-tail Family)

Typha latifolia L., Broad-leaved cat-tail. Abundant in marshes. *608, 705.*

DICOTYLEDONS

ACERACEAE (Maple Family)

Acer rubrum L., Red maple. Abundant in mixed deciduous woods and lowland hardwoods. *786, 981.*

A. saccharum Marsh., Sugar maple. Local in mixed deciduous woods. *973, 984.*

A. spicatum Lam., Mountain maple. Local in very moist woods near Nordhouse Lake. *848, 944.*

ANACARDIACEAE (Cashew Family)

Rhus copallina L., Shining sumac. Rare, one small tree found beside Nurnburg Rd. *954.*

Toxicodendron radicans var. *rydbergii* (Rydb.) Erskine, Poison ivy. Common on foredune and wooded bank behind it. *972.*

APOCYNACEAE (Dogbane Family)

Apocynum androsaemifolium L., Spreading dogbane (mid July–early Aug.). Local along roadsides. *658.*

AQUIFOLIACEAE (Holly Family)

Ilex verticillata (L.) Gray, Michigan holly (July). Occasional on pond edges and lowland hardwoods. *595, 598.*

Nemopanthus mucronatus (L.) Trel., Mountain holly (May). Abundant surrounding bogs and other wet places. *309, 319, 654, 656.*

ARALIACEAE (Ginseng Family)

Aralia hispida Vent., Bristly sarsaparilla. Local in open sites along FR 5356. *904.*

A. nudicaulis L., Wild Sarsaparilla (late May–early June). Occasional in woods bordering open dunes. *394, 712.*

ASCLEPIADACEAE (Milkweed Family)

Asclepias incarnata L., rare, only one plant found in wet area along new powerline clearing.

A. syriaca L., Common milkweed (July). Common in protected sites on dunes and roadsides. *625, 682, 801.*

BERBERIDACEAE (Barberry Family)

Berberis thunbergii DC., rare on foredune Sec. 27. *913.*

BETULACEAE (Birch Family)

Alnus rugosa (Du Roi) Spreng., Speckled alder. Abundant in lowland sites on marginal sand apron, often forming dense stands. *885, 924.*

Betula alleghaniensis Britt., Yellow birch. Frequent in cedar swamp and near bog edges. *3263.*

B. papyrifera Marsh., White birch. Common in both mixed deciduous and lowland hardwoods. *327, 391, 783, 792.*

Ostrya virginiana (Mill.) K. Koch, Ironwood. Rare, in an open site along wooded bank behind foredune. *729, 917.*

BORAGINACEAE (Forget-me-not Family)

Cynoglossum boreale Fern., (late May–early June). Occasional in mixed deciduous woods near open dunes. *393, 628.*

Lithospermum caroliniense (Walt.) Mac Mill., Puccoon (late May–mid July). Common along foredune. *406, 529.*

CAMPANULACEAE (Harebell Family)

Campanula rotundifolia L., Bluebell (late June–late July). Common on blowouts and foredune and in woods near open sand. *454, 577.*

Lobelia cardinalis L., Cardinal flower (Aug.). Local in lowland hardwoods and in old powerline clearing near cedar swamp. *807.*

L. kalmii L., Kalm's lobelia (Aug.). Local on edges of dune pools. *736.*

L. spicata Lam., Pale-spike lobelia (July). Frequent in moist open grassy sites. *498, 618, 646.*

CAPRIFOLIACEAE (Honeysuckle Family)

Diervilla lonicera Mill., Bush honeysuckle (late June-mid July). Common in oak woods and base of wooded slope behind foredune. *463, 527.*

Linnaea borealis L., Twinflower (early June-mid July). Common near edges of open sand and moist areas in woods behind dune front. *392, 466.*

Lonicera canadensis Marsh., Fly honeysuckle. Occasional on wooded bank behind foredune and in mixed deciduous woods. *527, 976.*

L. dioica L., Wild honeysuckle. Occasional among the shrubs on wooded bank behind the foredune. *396.*

Viburnum acerifolium L., Maple-leaved viburnum (June). Frequent in woods bordering open sand. *430, 524.*

V. cassinoides L., common on edges of bogs and other wet areas. *895.*

CARYOPHYLLACEAE (Pink Family)

Arenaria serpyllifolia L., Thyme-leaved sandwort (mid May–late June). Common along roadsides. *334, 380, 389, 441.*

Cerastium fontanum Baumg., Common mouse-eared chickweed (late June–mid July). Common in open sites and along roadsides. *461, 473, 531.*

Dianthus armeria L., Deptford-pink (late June–mid Aug.). Local along old powerline clearing. *726.*

Silene pratensis (Rafn) Godron & Grn., White campion (late June–mid July). Local in open roadsides. *565.*

S. antirrhina L., Catchfly (July). Occasional in old powerline clearling and along roadsides. *458, 662.*

Stellaria media (L.) Vill., Common chickweed (late June–mid July). Local in very moist shady sites of Nipissing trail. *415.*

CISTACEAE (Rockrose Family)

Helianthemum canadense (L.) Michx., Frostweed (June). Occasional in open sites and oak woods. *501.*

Hudsonia tomentosa Nutt., Beach-heath (mid June–early July). Occasional on open dunes behind foredune or near jack pine stands. *465.*

COMPOSITAE (Composite Family)

Achillea millefolium L., Common yarrow (mid June–early July). Local in open sites near dunes and jack pine stands. *414, 497.*

Anaphalis margaritacea (L.) Benth. & Hook., Pearly everlasing (early Aug.–early Sept.). Frequent near foredune and in jack pine stands. *725, 843.*

Antennaria plantaginifolia (L.) Richards, Pussytoes (May). Frequent in open sites. *311, 333.*

Arctium minus Schk., Burdock. Local at end of Nurnburg Rd.

Artemisia caudata Michx., Tall wormwood (late July–Sept.). Common on open dunes and foredune. *814.*

Aster laevis L., (Sept.). Common in moist open sites and jack pine stands. *915, 922, 966.*

A. lateriflorus (L.) Britt., (late Aug.–Sept.). Common in open moist sites and roadsides. *899, 934, 971.*

A. macrophyllus L., Large-leaved aster (Sept.). Common on wooded bank behind foredune. *910, 914.*

A. tradescanti L., (late Aug.–Sept.). Common in open, moist sandy sites near Nordhouse Lake and dune pools. *748, 862, 952, 967.*

A. vimineus Lam., (late Aug.–Sept.). Frequent in open sites. *844, 953, 964.*

Bidens frondosa L., (late Aug.–Sept.). Occasional in wet open sites. *959.*

Centaurea maculosa Lam., Spotted knapweed (early July–late Aug.). Abundant in open sites and along roadsides. *666, 730, 828.*

Chrysanthemum leucanthemum L., Ox-eye daisy (July). Frequent along roadsides. *553, 564.*

Cichorium intybus L., Common Chicory (mid July–late Aug.). Frequent along roadsides. *826.*

Cirsium pitcheri (Torr.) T. & G., Pitcher's thistle (late June–Sept.). Frequent on slightly stabilized dunes near blowouts and foredune. *631.*

C. vulgare (Savi) Tenore., Bull thistle (Aug.). Occasional along roadsides and jack pine stands. *789, 834.*

Erigeron strigosus Muhl., (late July–late Aug.). Frequent in open sites. *629, 724, 780.*

Eupatorium perfoliatum L., Boneset (Aug.). Local in moist sand near dune pools. *756.*

Hieracium aurantiacum L., Orange hawkweed (June). Common in open sites and along roadsides. *379, 418, 532, 549.*

H. canadense Michx., (late Aug.–early Sept.). Occasional in moist open areas. *764.*

H. venosum L., (late June–mid July). Common in open sites. *416, 615.*

Hypochaeris radicata L., (late July–early Aug.). Local along roadsides. *660.*

Krigia virginica (L.) Willd., Dwarf dandelion (mid June–early July). Local along open trails. *345, 366.*

Prenanthes alba L., White lettuce (Sept.). Local in open moist sites of old powerline clearing and foredune. *906, 961.*

Rudbeckia hirta L., Black-eyed Susan (Aug.). Rare on dune pannes. *735.*

Senecio pauperculus Michx., Balsam ragwort (early July–early Aug.). Common in moist sandy soil. *457, 535, 697.*

Solidago caesia L., Blue stem goldenrod (Sept.). Common in moist open sites. *911, 939, 960, 963, 970.*

S. canadensis L., (late Aug.–early Sept.). Occasional on moist open dunes. *811.*

S. graminifolia (L.) Salisb., Grass-leaved goldenrod (mid–late Aug.). Frequent by dune pools and pannes. *746.*

S. nemoralis Ait., Gray goldenrod (Sept.). Common in moist open sites. *923, 927, 935, 951, 960a, 962.*

S. rugosa Mill., (Sept.). Occasional along roadsides. *970.*

S. spathulata DC., (Sept.). Frequent on foredune. *907, 912.*

Taraxacum officinale Weber, Dandelion (mid May–early June). Occasional along roadsides and in open sites. *312.*

Tragopogon dubius Scop., Goat's beard (June). Frequent on open sites and along roadsides. *410, 520.*

CORNACEAE (Dogwood Family)

Cornus canadensis L., Bunchberry (mid May–late June). Common in mixed deciduous woods and red pine woods. *348, 413, 484, 781.*

C. stolonifera Michx., Red-osier (mid July–mid Aug.). Common in moist open sites, meadow, and foredune. *362, 403, 788.*

CRUCIFERAE (Mustard Family)

Arabis lyrata L., Sand cress (early May–late Aug.). Common on open dunes and along some roadsides. *329, 335, 433, 750, 892.*

Barbarea vulgaris R. Br., Winter cress (May). Occasional along roadsides. *331.*

Berteroa incana (L.) DC., Hoary alyssum (late May–early June). Occasional along roadsides. *451, 556.*

Cakile edentula (Bigel.) Hook., Sea-rocket (mid July–late Aug.). Common on open flat sand especially between strand and foredune. *733, 861.*

Lepidium campestre (L.) R. Br., (mid May–mid June). Occasional along roadsides. *330, 388.*

Nasturtium officinale R. Br., Water cress. Local in moist spot on old powerline clearing near cedar swamp. *990.*

DROSERACEAE (Sundew Family)

Drosera rotundifolia L., Round-leaved sundew (mid–late Aug.). Rare on mossy logs and stumps where small stream crosses old powerline clearing near cedar swamp. *804.*

ELAEAGNACEAE (Oleaster Family)

Shepherdia canadensis (L.) Nutt., Buffalo-berry. Local in shade of wooded bank behind foredune. *538.*

ERICACEAE (Heath Family)

Arctostaphylos uva-ursi (L.) Spreng., Bearberry (May). Common mat former on dunes near jack pine stands. *336, 759.*

Chamaedaphne calyculata (L.) Moench., Leatherleaf (late April–mid May). Abundant in bogs and open low places. *317, 325.*

Chimaphila maculata (L.) Pursh, Spotted wintergreen (late July–mid Aug.). Rare, only found in jack pine stands. *798.*

Epigaea repens L., Trailing arbutus (late April–early May). Common in oak woods. *300.*

Gaultheria hispidula (L.) Muhl., Creeping snowberry. Rare on logs in the cedar swamp and in the boundary clearing on its south side. *995.*

G. procumbens L., Wintergreen (mid July-mid Aug.). Common throughout all forests, but absent in very wet sites. *585, 772.*

Gaylussacia baccata (Wang.) K. Koch, Huckleberry. Abundant in oak woods. *364, 810, 847, 901.*

Kalmia polifolia Wang., Swamp-laurel. Locally scattered in bogs of Sec. 25. *958.*

Moneses uniflora (L.) Gray, One-flowered wintergreen (June). Rare, a small station observed in jack pine stand in Sec. 33, and one individual along the wooded bank behind the foredune of Sec. 27. *987.*

Monotropa hypopithys L., Pine sap (early June–mid Aug.). Common in mixed deciduous woods. *523, 587, 875.*

M. uniflora L., Indian pipe (early July–mid Aug.). Common in mixed deciduous woods. *586.*

Pyrola asarifolia Michx., Pink pyrola (July). Occasional in mixed deciduous woods. *563, 573.*

P. elliptica Nutt., Shinleaf (July). Occasional in woods edge just bordering open sand. *578.*

P. secunda L., One-sided pyrola (July). Occasional in woods edge just bordering open sand. *578.*

Vaccinium angustifolium Ait., Low sweet blueberry (mid June–early July). Wet woods and moist open depressions. *596.*

V. macrocarpon Ait., Large cranberry. Occasional in *Sphagnum* depressions of bogs and jack pine stands. *845, 863.*

V. myrtilloides Michx., Velvetleaf blueberry (mid June–early July). Lowland hardwoods and moist open depressions. *596.*

V. oxycoccus L., Small cranberry. Local in bogs of Sec. 25. *657.*

EUPHORBIACEAE (Spurge Family)

Euphorbia polygonifolia L., Seaside spurge (late July–mid Aug.). Occasionally forming rosettes on bare sand. *891.*

FAGACEAE (Beech Family)

Fagus grandifolia Ehrh., Beech. Common in mixed deciduous woods. *784.*

Quercus alba L., White oak. Common on wooded dune ridges. *956.*

Q. rubra L., Red oak. Common on wooded dune ridges and occasional in mixed deciduous woods. *916.*

Q. velutina Lam., Black oak. Common on old dune ridges. *365, 922, 957.*

GENTIANACEAE (Gentian Family)

Bartonia virginica (L.) BSP., local in wet lowland hardwoods. *779.*

Gentiana andrewsii Griseb., Closed gentian (Sept.). Rare, only a few plants in moist area at foot of wooded bank behind foredune. *937.*

GROSSULARIACEAE (Gooseberry Family)

Ribes cynosbati L., Prickly gooseberry. Local in woods bordering open sand. *711.*

GUTTIFERAE (St. John's-wort Family)

Hypericum kalmianum L., Kalm's St. John's-wort (mid July–early Aug.). Frequent in meadow and along foredune. *633, 652, 698, 753.*

H. majus (Gray) Britt., local in moist depressions along old powerline clearing. *719.*

H. perforatum L., Common St. John's-wort (late June–late July). Roadsides and other open sites. *521, 667.*

Triadenum fraseri (Spach) Gl. (mid July–late Aug.). Frequent at edges of ponds and bogs. *879.*

HAMAMELIDACEAE (Witch-hazel Family)

Hamamelis virginiana L., Witch-hazel. Frequently scattered throughout oak woods. *400, 925.*

LABIATAE (Mint Family)

Lycopus uniflorus Michx., (early July-late Aug.). Common in wet shaded areas. *717, 727, 774, 887.*

Mentha arvensis L., (July). Local in open sites around Nordhouse Lake and meadow. *694.*

Monarda fistulosa L., (mid July–mid Aug.). Frequent in open sites near foredune. *701, 731.*

M. punctata L., Horsemint (Aug.). Frequent on grassy dunes. *713.*

Prunella vulgaris L., Self-heal (July). Common in roadsides and other open sites. *421, 428, 482, 517, 546.*

Satureja vulgaris (L.) Fritsch, Basil. Common in open sites. *467, 493, 672.*

Scutellaria lateriflora L., Mad Dog Skullcap. Common in lowland hardwoods. *770, 806.*

Stachys hyssopifolia Michx., (July). Local on banks of Nordhouse Lake. *696.*

LAURACEAE (Laurel Family)

Sassafras albidum (Nutt.) Nees., frequent throughout oak woods and around edges of the meadow and Nordhouse Lake. *920, 996.*

LEGUMINOSAE (Bean Family)

Lathyrus japonicus Willd., Beach pea (mid June–late July). Common on foredune and grassy dunes. *539, 755.*

Medicago lupulina L., Black medic (early June–early July). Common along roadsides. *387, 516.*

Melilotus alba Medic., White sweet clover (early July–late Aug.). Frequent on roadsides. *566.*

Trifolium pratense L., Red clover (July). Occasional along roadsides. *636.*

T. repens L., White clover (late June–late July). Frequent along roadsides and in shaded two-tracks. *425, 475, 547.*

Vicia villosa Roth, Hairy vetch (Sept.). Rare along roadsides. *969.*

LINACEAE (Flax Family)

Linum striatum Walter, Yellow flax. Local in moist jack pine stands. *850.*

LYTHRACEAE (Loosestrife Family)

Rotala ramosior (L.) Koehne, Tooth-cup (mid July–mid Aug.). Local along mud flats of Nordhouse Lake. *692.*

MOLLUGINACEAE (Carpetweed Family)

Mollugo verticillata L., Carpetweed (Aug.). Local on mud flats of Nordhouse Lake. *842.*

MYRICACEAE (Bayberry Family)

Comptonia peregrina (L.) Coult., Sweet-fern. Occasional in sandy, disturbed sites such as roadsides and clear-cuts. *408, 519*

Myrica gale L., Sweet gale. Local in Lost Lakes bog-swamp. *796, 998.*

NYSSACEAE (Tupelo Family)

Nyssa sylvatica Marsh., Black-gum. Local in mixed deciduous woods and along roadsides. *831.*

OLEACEAE (Olive Family)

Fraxinus pennsylvanica Marsh., Red ash. Frequent in both mixed deciduous and lowland hardwoods and around Nordhouse Lake. *612.*

ONAGRACEAE (Evening Primrose Family)

Circaea alpina L., Dwarf enchanter's nightshade (late June–mid July). Common in moist to wet shaded sites. *412, 490, 528.*

Oenothera oaksiana (Gray) Watson & Coult., Evening primrose (mid July–early Sept.). Common in open sites and on foredune. *732, 889, 893.*

O. perennis L., Sundrops (late June–mid Aug.). Frequent in open sunny sites. *456, 648, 763, 888.*

OROBANCHACEAE (Broomrape Family)

Conopholis americana (L.) Wallr., Squawroot. Common in mixed deciduous woods. *429, 488, 536.*

Epifagus virginiana (L.) Bart., Beech-drops. Common under beeches in mixed deciduous woods. *840, 941.*

Orobanche fasciculata Nutt., Broomrape. Rare on open dunes of Secs. 32 and 33.

OXALIDACEAE (Wood-sorrel Family)

Oxalis fontana Bunge (early July–early Aug.). Local in moist woods near Nordhouse Lake. *621.*

PLANTAGINACEAE (Plantain Family)

Plantago lanceolata L., English plantain. Occasional along open roadsides. *462, 496.*

P. rugellii Decne., Pale plantain. Occasional along open roadsides. *462a, 495.*

POLYGALACEAE (Milkwort Family)

Polygala paucifolia Willd., Flowering wintergreen (May). Common in mixed deciduous woods, shaded bank behind foredune, and cedar swamp. *302, 314, 324.*

POLYGONACEAE (Smartweed Family)

Polygonella articulata (L.) Meissn., (Sept.). Frequent on stabilized sand dunes and in local upland sites on the marginal dune apron near the bogs. *812, 928, 965.*

Polygonum amphibium L., (mid July–late Aug.). Common in pools and at Nordhouse Lake. *699, 841, 876.*

P. hydropiperoides Michx., (late Aug.–early Sept.). Local in alder thickets. *878, 936.*

Rumex acetosella L., Red sorrel (mid May–mid July). Common in aspen woods and open sites. *355, 419, 423, 444, 482a, 606, 620.*

R. crispus L., Sour dock. Local in moist open sites. *567, 623.*

R. obtusifolius L., Bitter dock. Occasional in mixed deciduous woods. *720.*

PRIMULACEAE (Primrose Family)

Lysimachia lanceolata Walt., (mid June–early Aug.). Common in moist, open sites. *616, 647.*

L. thyrsiflora L., Tufted loosestrife (late June–early July). Frequent in open wet sites and alder thickets. *471, 669.*

Trientalis borealis Raf., Starflower (mid May–late June). Common in mixed deciduous woods and red pine woods at bog edges. *351.*

RANUNCULACEAE (Buttercup Family)

Actaea pachypoda Ell., White baneberry (late May–early June). Occasional in mixed deciduous vegetation islands on the dunes near Lake Michigan. *395, 968.*

Anemone canadensis L., Canada anemone (early June–early Sept.). Local in moist shaded sites around Nordhouse Lake. *617, 622, 695.*

Aquilegia canadensis L., Wild columbine (late May–late June). Local on wooded bank behind foredune. *399.*

Caltha palustris L., Marsh-marigold (mid May–early June). Occasional in standing water of alder thickets and small streams. *301, 338.*

Coptis trifolia (L.) Salisb., Goldthread (early–late May). Local in cedar swamp. *320, 375.*

Hepatica americana (DC.) Ker, Round-leaved hepatica. Local in rich deciduous woods of Sec. 26. *588.*

Ranunculus recurvatus Poir., (early–late June). Local on edge of vernal pond at end of Algoma trail, Sec. 27 NE ¼. *342, 994.*

ROSACEAE (Rose Family)

Amelanchier interior Nielson, (May). Common in open woods near trails and roads. *610.*

A. laevis Wieg., (May). Common in open woods near trails and roads. *310, 318, 655.*

Aronia prunifolia (Marsh.) Render, Chokeberry. Frequent on edges of bogs and other wet sites. *385, 800, 847a, 926.*

Fragaria virginiana Mill., Wild strawberry (mid May–early June). Common on open ground and on wooded bank behind foredune. *305, 313, 382, 397, 534.*

Geum allepicum Jacq., Cream-colored avens. Rare in woods just south of meadow. *773.*

Potentilla anserina L., Silverweed (late July–late Aug.). Occasional along edges of dune pools. *757.*

P. argentea L., Silvery cinquefoil (July). Frequent in open sites and roadsides. *492, 555, 659.*

P. norvegica L., Rough cinquefoil (late July–mid Aug.). Occasional in moist sites in oak woods near dunes. *459.*

P. palustris (L.) Scop., Marsh cinquefoil. Local on edges of ponds. *782.*

P. recta L., Sulfur cinquefoil (July). Common along roadsides. *551.*

P. simplex Michx., Old-field cinquefoil (June). Common in grassy areas near Nordhouse Lake and meadow. *354, 427.*

Prunus pensylvanica L. f., Pin cherry (late June–early July). Local on bank behind foredune. *728.*

P. pumila L., Sand cherry (mid May–early June). Common on and near foredune. *377, 356, 723.*

P. serotina Ehrh., Wild black cherry (late May–mid June). Local in mixed deciduous woods and edges of open sites. *854, 856.*

P. virginiana L., Choke cherry (June). Local in grassy sites south of Nordhouse Lake. *360, 405, 790.*

Rosa blanda Ait., Wild rose (July). Local on foredune. *540.*

R. carolina L., Pasture rose (July). Local in grassy sites south of Nordhouse Lake. *611.*

R. palustris Marsh., Swamp rose (mid Aug.–early Aug.). Rare on edge of marsh. *886.*

Rubus flagellaris Willd., Northern dewberry. Frequent on open grassy sites near Nordhouse Lake and meadow. *505, 506, 787.*

R. hispidus L., Swamp dewberry (mid July–early Aug.). Common in wet sites and bogs. *541, 572, 597, 898.*

R. strigosus Michx., Wild red raspberry. Occasional in jack pine stands. *851.*

Sorbus americana Marsh., Mountain-ash. Local in wet lowland woods. *931.*

Spiraea alba Du Roi, Meadowsweet. Local in meadow. *651.*

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L., Buttonbush (Aug.). Local on edge of Nordhouse Lake. *829.*

Galium pilosum Ait., (Aug.). Local in moist jack pine stands. *747.*

G. tinctorium L., occasional in open wet sites. *600, 734.*

G. triflorum Michx., Sweet scented bedstraw (June). Common in both mixed deciduous and lowland hardwoods. *411, 442, 453, 477.*

Houstonia longifolia Gaertn., (late May–late June). Common in moist open sites and surrounding woods. *352, 386, 420, 522.*

Mitchella repens L., Partridgeberry (early–mid July). Common in mixed deciduous woods. *491, 874.*

SALICACEAE (Willow Family)

Populus balsamifera L., Balsam poplar. Occasional on foredune. *890.*

P. deltoides Marsh., Cottonwood. Common on dunes near jack pines and around Nordhouse Lake. *758, 791, 838, 839.*

P. grandidentata Michx., Big-tooth aspen. Common in woods and at wood edges and roadsides. *328.*

P. nigra L., Lombardy poplar. Local on foredune. *3264.*

P. tremuloides Michx., Quaking aspen. Occasional along roadsides and around ponds in lowland hardwoods. *836.*

Salix cordata Michx., occasional on foredune near wooded slope. *407a.*

S. discolor Muhl., frequent in jack pine stands. *754.*

S. exigua Nutt., common on foredune and dune pannes. *390, 525, 860.*

S. humilis Marsh., occasional along roadsides. *835.*

S. lucida Muhl., frequent on dune pannes. *407, 853.*

S. rigida Muhl., occasional along roadsides. *832.*

S. petiolaris Sm., local in meadow. *650.*

SAXIFRAGACEAE (Saxifrage Family)

Mitella nuda L., Naked miterwort (June). Local scattered throughout cedar swamp. *376.*

SCROPHULARIACEAE (Figwort Family)

Melampyrum lineare Desr., Cow-wheat (late June–late Aug.). Common in oak woods. *417, 518, 550.*

Mimulus ringens L., (mid–late July). Local in wet sites in mixed deciduous woods. *624.*

Pedicularis canadensis L., Wood betony (late May–mid June). Frequent in oak woods and wooded bank behind foredune. *344, 361, 398.*

Verbascum thapsus L., Common mullein (late July–late Aug.). Local in dry open sites. *721.*

Veronica arvensis L., (mid May–early July). Local along roadsides. *557.*

V. scutellata L., (July). Occasional in wet shaded sites. *470, 561, 645.*

TILIACEAE (Basswood Family)

Tilia americana L., Basswood. Locally associated with sugar maples in Sec. 26, and also occurring in a very small deciduous vegetation island of Secs. 33 and 34. *882.*

UMBELLIFERAE (Parsley Family)

Cryptotaenia canadensis (L.) DC., Honewort. Local in wet lowland hardwoods near Nordhouse Lake. *502.*

Daucus carota L., Wild carrot (late July–late Aug.). Common along roadsides. *661, 830.*

Osmorhiza claytonii (Michx.) C. B. Clarke, Sweet cicely. Local in rich deciduous woods under sugar maples. *983.*

Sium suave Walter, Water-parsnip (mid Aug.–early Sept.). Occasional in wet sites in mixed deciduous woods. *762.*

Taenidia integerrima (L.) Drude, Yellow pimpernel (early June–mid July). Frequent in open sites in oak woods. *381, 530.*

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Sw., frequent in cool, shaded, wet sites. *704, 949.*

VIOLACEAE (Violet Family)

Viola conspersa Reichenb., Dog violet. Local in wet areas. *307.*

V. cucullata Ait., Marsh violet (May). Common in cool shady, wet sites. *304, 322, 343, 353.*

V. macloskyi F. E. Lloyd, Smooth white violet (May). Local in alder thickets and cedar swamp. *306, 321, 374.*

V. pubescens Ait., Yellow violet (May). Rare in wet woods. *340.*

V. sagittata Ait., Arrow-leaved violet (May). Local in very wet deciduous woods or meadow edges. *303, 315.*

VITACEAE (Grape Family)

Vitis riparia Michx., Riverbank grape (late May–mid June). Common trailing on foredune and climbing on trees bordering open sand. *526, 722.*

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CONTENTS

On the cover: *Open dunes within proposed Nordhouse Dunes Wilderness, Mason County, Michigan. Photo by Brian T. Hazlett, July 1979.*

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INDEX TO VOLUMES 16-25

This index follows the format and philosophy established by Dr. Edward G. Voss for indices to volumes 1-15. As in previous indices, all scientific names of genera and species, titles (by important words), authors, and subjects are included. NOT included in the index are: news items, editorial notes, items in literature lists or summaries, common names or names of taxa higher than genus. Reviews are lists by title under "Reviews". "Publications of Interest" are not listed by title, but volume and page numbers for the heading are given.

We have broadened the coverage of species listed in the index by including species noted to be associated in a given habitat or with major species under discussion. We did not include species mentioned in passing but not found at the study sites. For a given article, only the first use of each species is cited unless the species was included as part of a list, in which case the citation is for the first occurrance in the first list. One exception was the species noted in the article, "Nature Preserves in Michigan, 1920-1979", by Susan R. Crispin. In this case, species were cited for each preserve. When a species is mentioned as part of a checklist, the only citation is to the checklist, even when the checklist is a companion paper to a more detailed study of a site. For example, species noted in B. Hazlett's two papers on the Nordhouse Dunes are indexed for part II (25: 74-92) and not part I (25: 125-139). A full citation of authors and title is only given for the first author; citation for all others authors are referred to the first author, e.g., "Sladky, Roberta J., see: Morley, Thomas, &, 22: 133-140".

All new names and new combinations appear in **bold face** type. Maps are collected under the heading "Distribution Maps", including some vegetation maps, etc.

We wish to acknowledge the help of Kevin Bradtke, Murray Cooper, William Luitje, Linda McIntyre, and Stephen Stephenson in entering citations into computer files; Tony Reznicek for providing a program used in the final collation of the citations; and Helen Smith for the loan of her computer when ours died. Martie Cochran, Annie and Gary Hannan, and Tony Reznicek helped by checking proof.

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111

CONTENTS

(*On the cover: Seed heads of swamp milkweed,* Asclepias incarnata. *Photo by Jim Weber.*)